

# SAE

# Journal

NOVEMBER 1957

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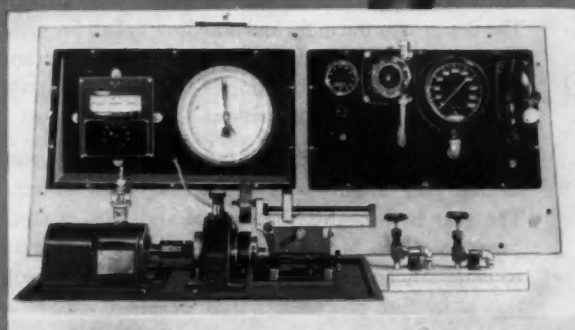
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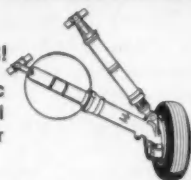
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### FUELS & LUBRICANTS

**Hot Fuel Handling Characteristics of 1956 Cars With and Without Air Conditioners, J. G. LILLARD, T. G. LIPSCOMB. Paper No. 140.** Presented June, 1957, 9 p. 29 cars, of which 19 were equipped with air conditioners, representing 12 makes were evaluated for fuel volatility requirements; data obtained showed that volatility limits were reduced on average of 0.6 lb RVP upon installation of unit and lowered another 1.3 lb RVP when operated, thus illustrating overall trend toward increasing vapor lock tendencies; possible improvements.

**Simplified Lubricant Recommendations for Logging Equipment, M. R. ZOFFEL. Paper No. 159.** Presented Aug., 1957, 6 p. Problems caused by complex lubricant recommendations from logger's viewpoint; items of which logging equipment consist are enumerated to demonstrate lubricant inventory problem of moderately sized outfit; complex and simplified recommendations for gasoline and diesel engine oil, gear oils and greases; schedule of inventory distribution; simplified program of multi purpose lubricants is suggested.

**New Developments in Multigrade Crankcase Motor Oils, J. A. MILLER, C. K. PARKER, JR. Paper No. 160.** Presented Aug., 1957, 21 p. Problem of deposits in passenger car engines can be overcome by use of new class of polymeric detergent oils; called commercially RPM Supreme Motor oil; laboratory and field data obtained with 10W-30 oils containing detergent and suitable level of zinc dithiophosphate; comparative performance of test and conventional oils; tables.

**New Horizons with New Gear Lubricants, L. RAYMOND. Paper No. 161.** Presented Aug., 1957, 17 p. Development of new type designated "Multipurpose-Type Gear Lubricant API Service GL-4" possessing anti-scoring advantages of active-sulphur type lubricants and desirable anti-wear and low friction characteristics of inactive type products; axle performance data of tests involving passenger cars, commercial, and military

vehicles; new axle test method for incorporation in upgrading version of Specification MIL-L-2105; reference gear lubricant scale.

**Multipurpose Greases—Logging Applications, H. A. WOODS, D. E. WOLLAM. Paper No. 162.** Presented Aug., 1957, 9 p. Correction of deficiencies of lithium 12-hydroxystearate multipurpose greases through suitable additives proved successful in obtaining good metal wetting and corrosion protection in presence of water; use of more viscous oil improved load carrying properties; future trends; comparison between lithium 12-hydroxystearate grease and new nonmelting inorganic microgel, now being developed by Shell Oil.

**of Multi-Purpose Lubricating Oils (Series 3), J. W. VOLLENTINE. Paper No. 163.** Presented Aug., 1957, 3 p. New set of test conditions developed to describe heavy duty diesel engine performance requirements of oils suitable for higher performance; oils developed to meet test requirements are known as Superior Lubricants (Series 3); test conditions used; slides show comparison of performance of Series 2 and Series 3 oils under operating conditions with 5½ x 6 in. supercharged engine used in shrimp boat.

**Ease of Maintenance—Simplified Lubrication, R. W. BEAL. Paper No. 180.** Presented Sept. 1957, 13 p. Mission and projects selected for study by Subcommittee XVI of CIMTC on

Symposium: Up-to-Date Evaluation

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Ease of Maintenance; summary of survey on present field lubrication practice of civilian and military users of construction and industrial type equipment; tentative standards for simplified lubrication; most practicable lubrication periods and seven types of lubricants; lubrication guide for machine mounting; future plans.

### GROUND VEHICLES

**Passenger Ride Comfort on Curved Track, R. FERGUSON. Paper No. 137.** Presented June, 1957, 14 p. Factors involved in design of track and equipment which affect ride comfort on curves; to review practices in regard to speed limitations in relation to track and modern passenger equipment, static and dynamic tests were made on eight railroads using ten passenger cars, each car representing some variant in current design practice; instrumentation used and test results on basis of which modified table of permissible speeds has been inclosed in AREA Manual and recommendations made.

**Instrument Applications to Riding Comfort, H. W. LARSEN. Paper No.**

138. Presented June, 1957, 8 p. Instrumentation available in vehicle ride and comfort testing, usually limited to measurement of motion, force, or sound, and ways in which they are employed; instrumentation involving electro-mechanical transducers; factors influencing choice of recording device; number of separate items of data required in truck suspension study and instrumentation used; use of binaural tape recording equipment.

**Engineering Considerations in Development of Air Cooled M. W. M. Diesel Engines, N. FODOR. Paper No. T35.** Presented Aug., 1957. Fundamental evaluation of air and water cooling engines, problems of air cooling and of component parts; combustion process and special problems arising from it; construction of air cooled MWM (Motoren-Werke Mannheim, AG) automotive and small stationary diesel engines, which include 1- to 4-cyl engines built as in-line engines, and 6- and 8-cyl V engines; design details and operating results.

**Matching Engine to Application, R. W. SINKS. Paper No. 143.** Presented June 1957, 9 p. Ways to improve fuel economy of any diesel powered unit are shown; examples of applications illustrate improvements in fuel consumption that can be made with engine speed; examination of difference between engine gross power and power available indicate three areas of parasitic loss: engine accessory, vehicle accessory, and power train component losses; engine power requirements; diagrams.

**Practical Aspects of Diesel Operations, F. R. NAIL. Paper No. 144.** Presented June 1957, 9 p. Materials testing process and examples of laboratory and controlled test results of Mack Trucks, Inc.; customer operations are reviewed to determine how actual usage agrees or disagrees with forecast expectations; economics of truck operation can be produced only by on-job tailoring and in accord with governing fundamental principles which are listed.

**Dynamics of Low Silhouette Hotchkiss Drive Line, R. H. BOLLINGER. Paper No. 119.** Presented June, 1957 10 p. Design procedure at Ford Motor Co. for eliminating noise and vibration from typical 3-joint driveshaft installation by means of dynamic force equations; use of digital IBM 702 computer to establish optimum 3-joint driveshaft design for use with Hotchkiss suspension; if best design possible is not satisfactory, method reveals critical areas, pertinence to design of cars of lower silhouette.

**Dynamics of Low Silhouette Torque Tube Drive Line, L. E. MULLER. Paper No. 120.** Presented June, 1957 7 p. Problems created by use of bent propeller shafts.

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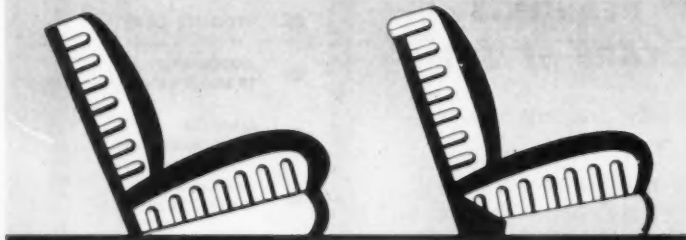
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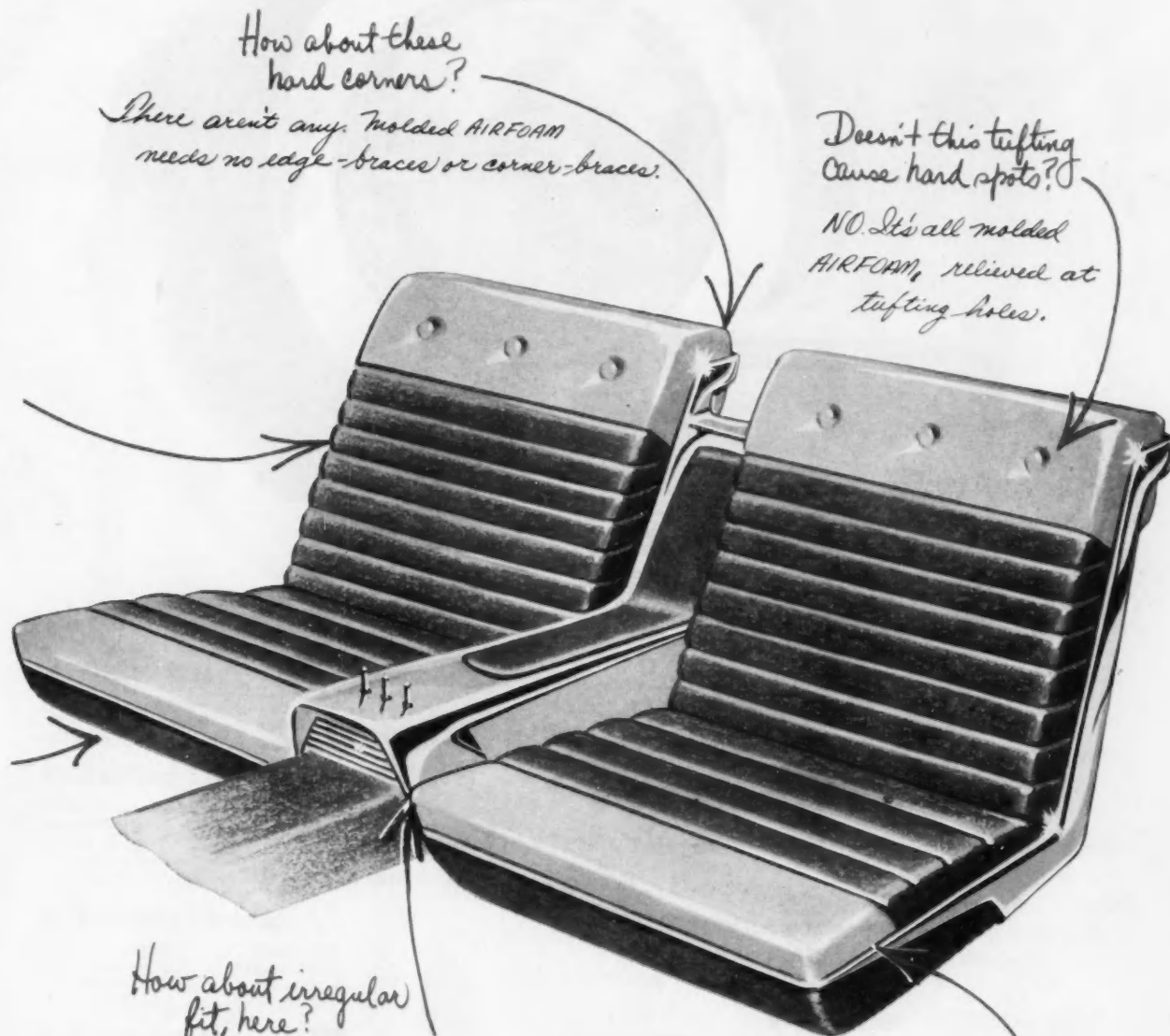
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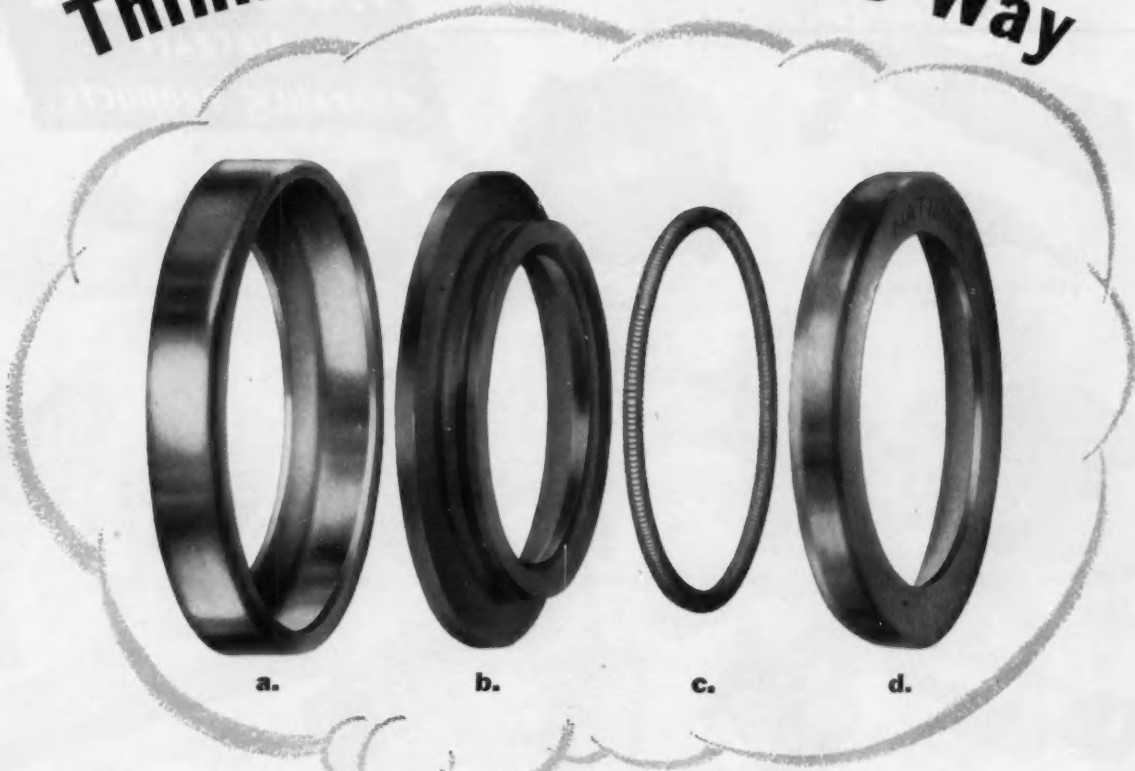
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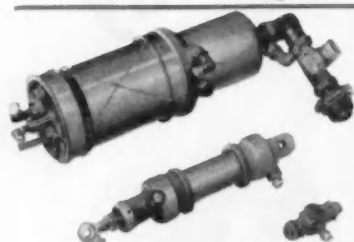
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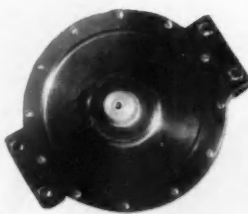


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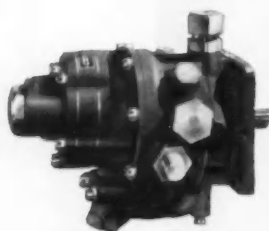
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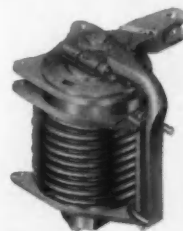
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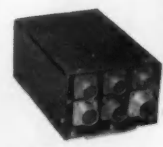
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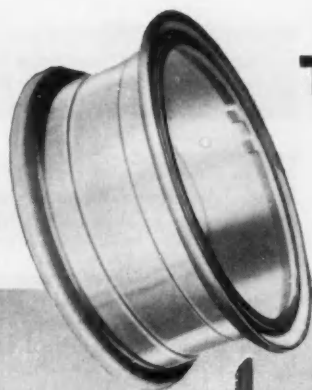
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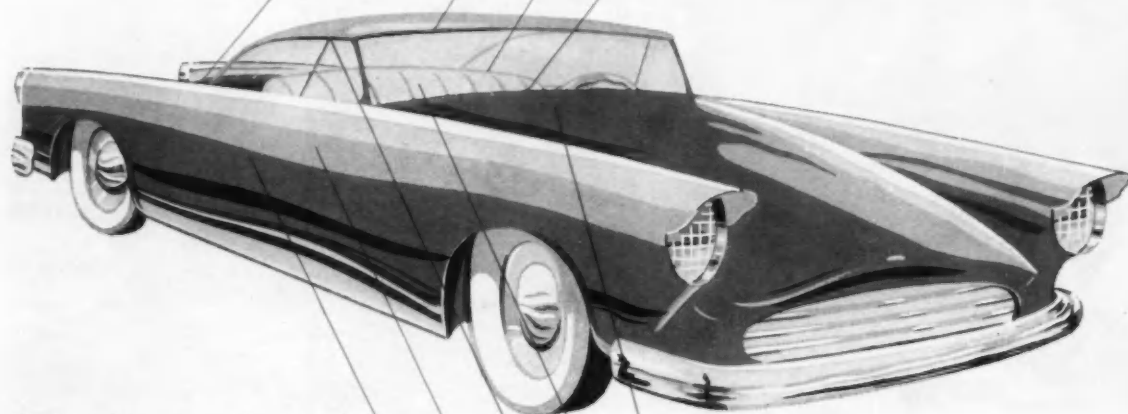
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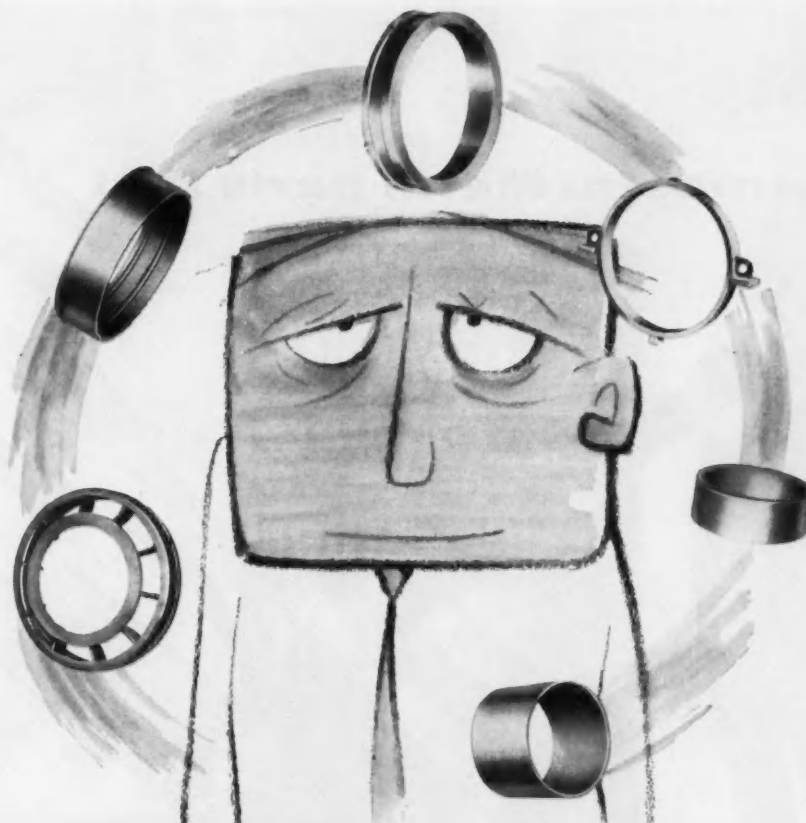
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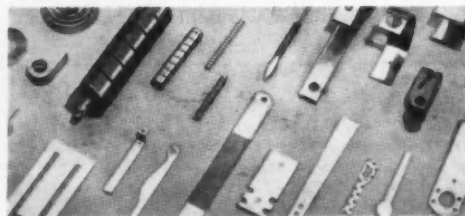
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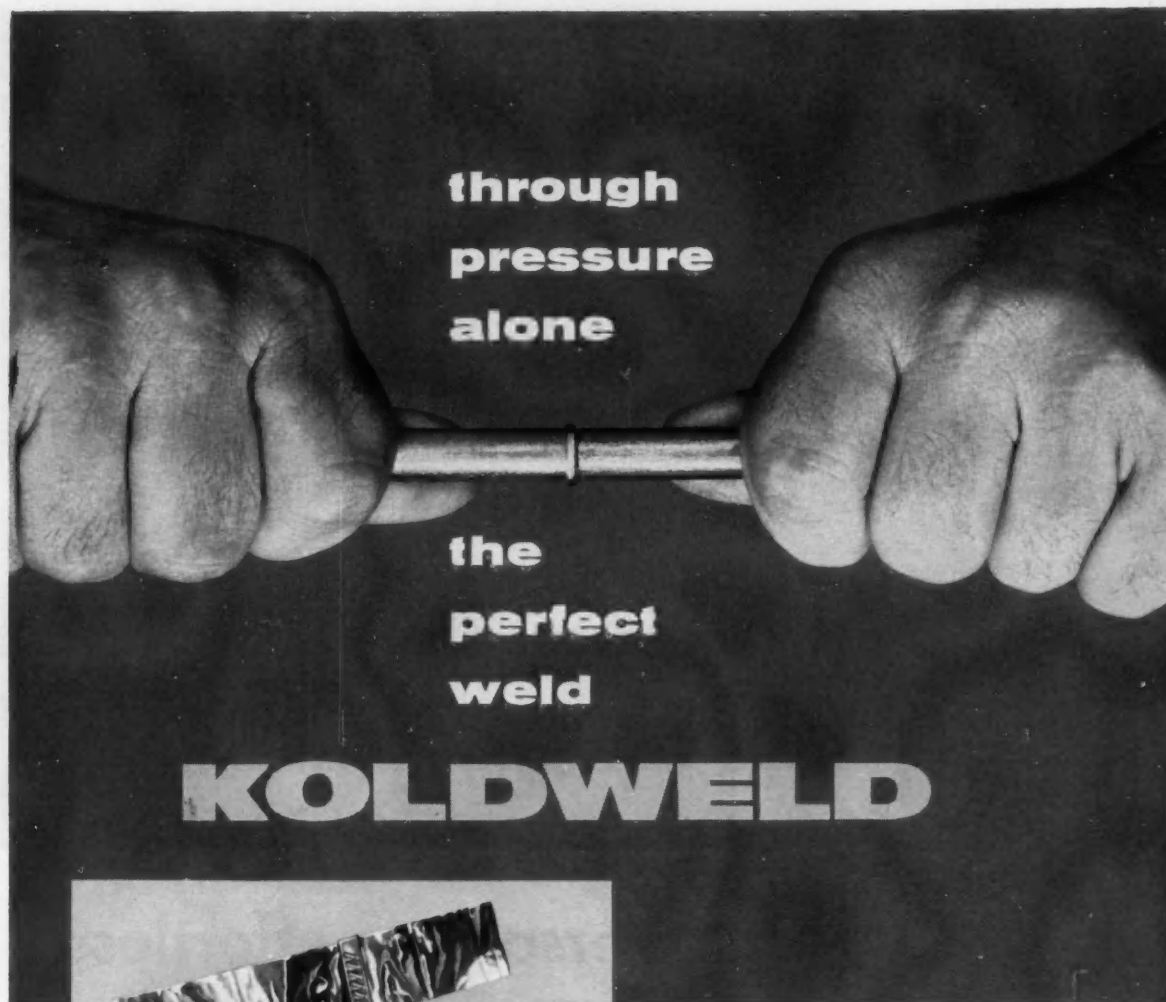
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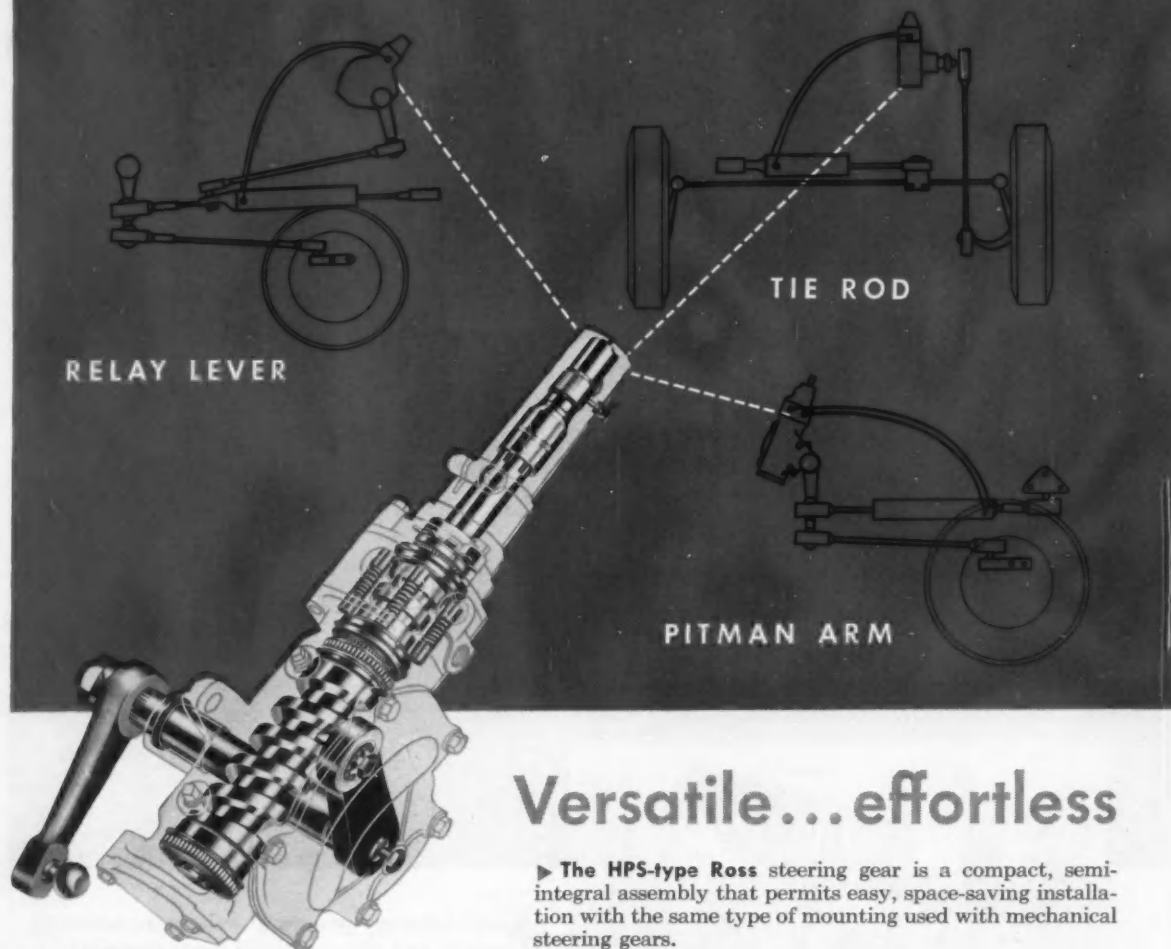
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## Versatile...effortless

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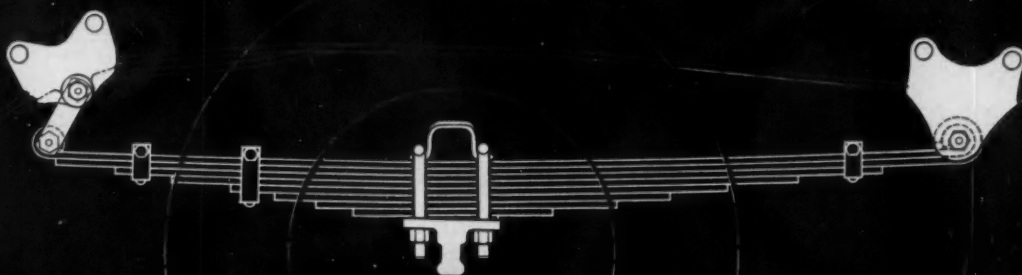
Ross makes all three types of hydraulic power steering—integral, semi-integral, and linkage—and invites discussion of any steering problem, power or manual.

# Ross HYDRAPOWER

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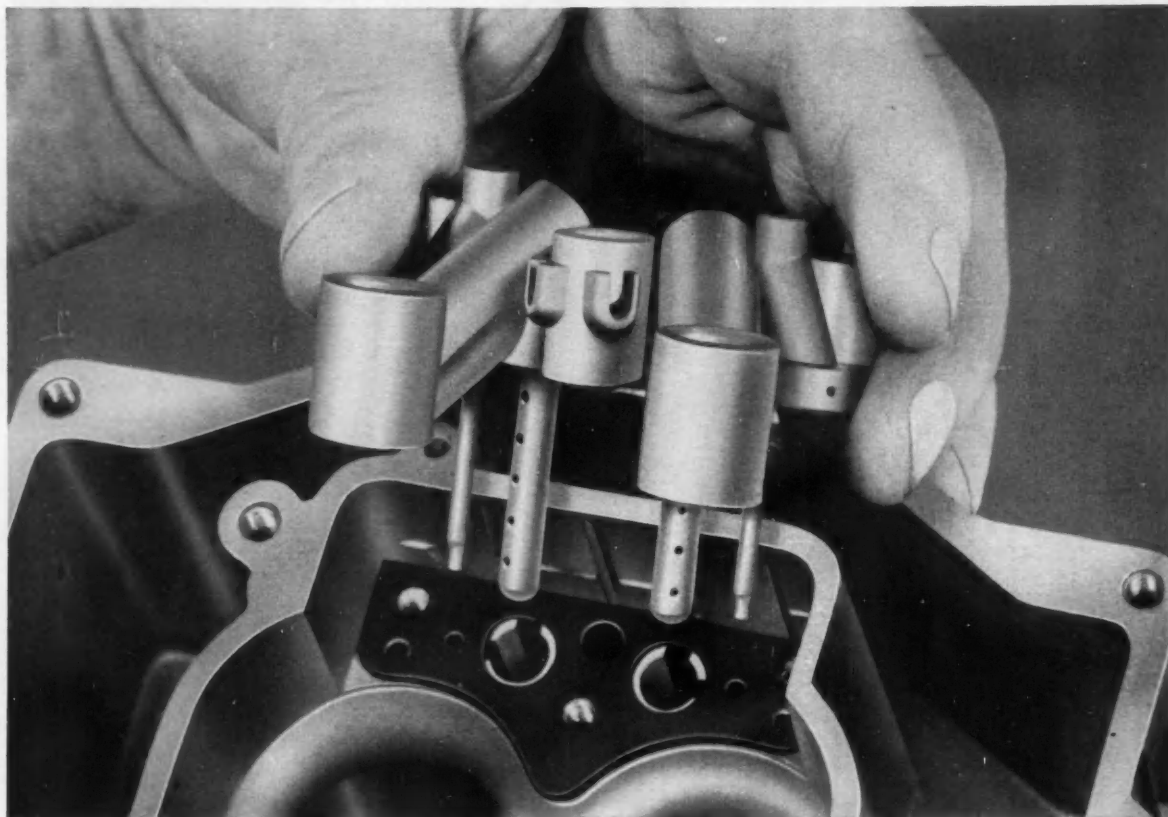
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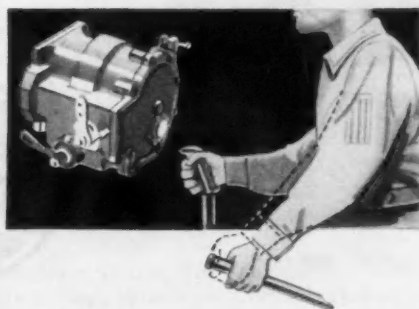


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Many times a helicopter pilot wishes he had three hands . . . one to govern direction, another to control the up, down or hover movement, and a third to regulate the throttle. Now, Curtiss-Wright, in cooperation with the U. S. Army and the U. S. Navy, answers this need for a "third hand" with the all-mechanical Automatic Throttle Control.

It makes the pilot's job much easier. He simply sets the desired engine speed with the regular twist-grip throttle . . . the Automatic Throttle Control takes over and keeps engine speed constant, automatically adjusting fuel flow to meet changing conditions.

The Automatic Throttle Control adds immeasurably to the safety and utility of helicopters . . . safeguards engine against overspeed. Planned for use in airships and other throttle-governing applications, it is one more example of the many cooperative contributions by Curtiss-Wright to America's leadership in air transportation.

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## For the Sake of Argument

*De Amicitia* . . .

By Norman G. Shidle

Friendship is the unfoldment of unity in the consciousness of two (or more) people.

It turns disagreements into blooms which reflect open minds; opposed tastes into paths for better understanding of *all* people. Friendship is a togetherness of minds as well as of hearts; of hearts as well as of minds.

Everyone yearns for friendship. But few want it badly enough to achieve as much of it as they yearn for . . . for friendship takes time. It takes time to achieve; time to maintain.

It is no happenstance that normal sentimental references are to "old" friends, "old" associates, and to "that old gang of mine." Most of us make a majority of deep friendships before we leave school; before we marry; before we raise families.

After we go to work, we get so busy "doing," we have little time for just "being". . . . And friendship is a matter of being, rather than of doing.


To stem deceleration in friendships, we usually turn backward; seek to fan old flames; to warm up old embers. Only at long last do we exclaim with Jimmy Durante: "It's a losin' proposition!"

Only then do we stop to think:

"Why, the past is always receding. We can't hold on to it, no matter how hard we try. It's sure to go farther and farther out of consciousness.

"Only the future can be deeply concerned in 'the unfoldment of unity in the consciousness of two people.' In the framework of its ideas and hopes and potentials can be nurtured never-ending friendships."

There's always tomorrow.



SURE, POWER STEERING  
MAKES THE JOB EASIER.  
BUT IT'S THE ADDED SAFETY  
THAT COUNTS MOST.

OUR POWER-STEERED  
RIGS STAY ON SCHEDULE  
BETTER, TOO.

EITHER WAY,  
POWER STEERING MAKES  
GOOD BUSINESS SENSE.

## THE CASE FOR POWER STEERING ON TRUCKS!

The trend to power steering on trucks is based on one very practical reason—operators of trucks equipped with power steering have invariably found that the added safety and greater operating efficiency of their vehicles have demonstrated that power steering is indeed a sound investment.

Truck drivers using power steering report less tension and fatigue in normal driving and appreciate the positive control that blocks road shock from chuck holes and prevents loss of control if the truck is forced out on a soft shoulder.

The dispatcher knows the importance of regularly maintained schedules. He is quite aware that with power steering drivers are more relaxed and are better drivers than tired drivers. Thus, power steering not only reduces the hazard of road accidents, but helps the driver to maintain established schedules through better vehicle control.

In short, power steering, by saving time and money, contributes materially to a more profitable operation.

Truck manufacturers are always eager to offer their customers features

that will make truck operation safer and more profitable and, at the same time, give their dealers every selling advantage.

That's why more and more truck manufacturers are offering performance-proven Bendix\* Power Steering as original factory equipment.

If you would like to know why power steering for trucks is perhaps even more logical than power steering for passenger cars, we have prepared an interesting folder on the subject.

Write for your copy today. We think you'll be convinced.

\*REG. U.S. PAT. OFF.

**Bendix** PRODUCTS DIVISION **South Bend IND.**



# More Load, Less Weight. . .

## is air suspension's gift to commercial vehicle designers.

Based on paper by

**D. J. LaBelle,**

GMC Truck & Coach Division, GMC

**T**HE reduced fatigue loads and constant platform height given truck-trailer combinations by use of air springs will up load-carrying capacities and reduce tare weights of future commercial vehicles. Four years and millions of miles of experience data have convinced GM truck engineers that major vehicle design improvements can be based on the assumption that air springs will perform as expected.

It is now clear, for instance, that air springs on buses and trucks have brought:

- Increased riding comfort.
- Constant platform height.
- Reduction in fatigue loads.
- Decreased maintenance costs.

So, the deflection "space" required by conventional suspensions can be designed into added payload space. Also, counting on decreased fatigue loads, the designer can select lighter materials and reduce the size of some parts.

The new concept of a heavy-duty highway tractor now possible may well compare with its present-day equivalent as follows:

1. Nearly 2000 lb less tare weight.
2. A 5-in. lower fifth-wheel height—for increased payload space.
3. A more comfortable ride—which will be easier on the driver, the cargo, and the equipment.
4. Decreased operating cost—because of lower maintenance requirements.
5. Constant floor height—for easier loading and unloading.

### More Payload

The increased payload capacity will result largely because air suspension—controlled by a leveling

valve—results in the same height empty or loaded. This permits the designer to place his floor line at loaded height and build his vehicle up to the maximum legal limit.

The deflection "space" required by conventional suspensions now becomes payload space. Each inch of space added here results in 21 cu ft of cargo space in a 35-ft trailer. Since conventional suspensions require some 3–5 in. of static deflection, the net gain in cubage is 60–100 cu ft.

Even more important than increased cube, is the reduction of tare weight. Every pound saved here means another pound of payload.

The amount of weight saved in the suspension itself, while appreciable, is not impressive. It is only when the entire vehicle is considered that really important weight savings can be accomplished.

### Fatigue Load No Worry

Also, the safety of worrying very much less about fatigue loads is proved by many durability tests such as those for which results are shown in Figs. 1 and 2. These tests indicate that considerably lighter construction can be used for grilles, fenders, hoods and other such components with no sacrifice in life.

Fig. 1, for example, shows the records obtained by mounting accelerometers on the trailer floor (over the fifth-wheel and over the trailer axles) of two vehicles—one equipped with conventional and the other with air springs.

The two vehicles were comparable in every respect except for the suspensions . . . and the tests were run on a very rough section of a black-top road.

In the leaf-spring-equipped combination, disturbances of the order of 3-cps were predominant. That indicates that the vehicle was riding on tires alone (without benefit of springs) since the frequency measured corresponds to that calculated for a system having 1-in. of static deflection . . . which is about normal for truck tires. The air suspension, as Fig. 1 shows, literally ironed out this disturbance.

Similar evidence that air springs can be relied upon to reduce fatigue loads is shown in Fig. 2. Here are shown results of strain-gage measurements at a critical point on the rear-axle housing. These data

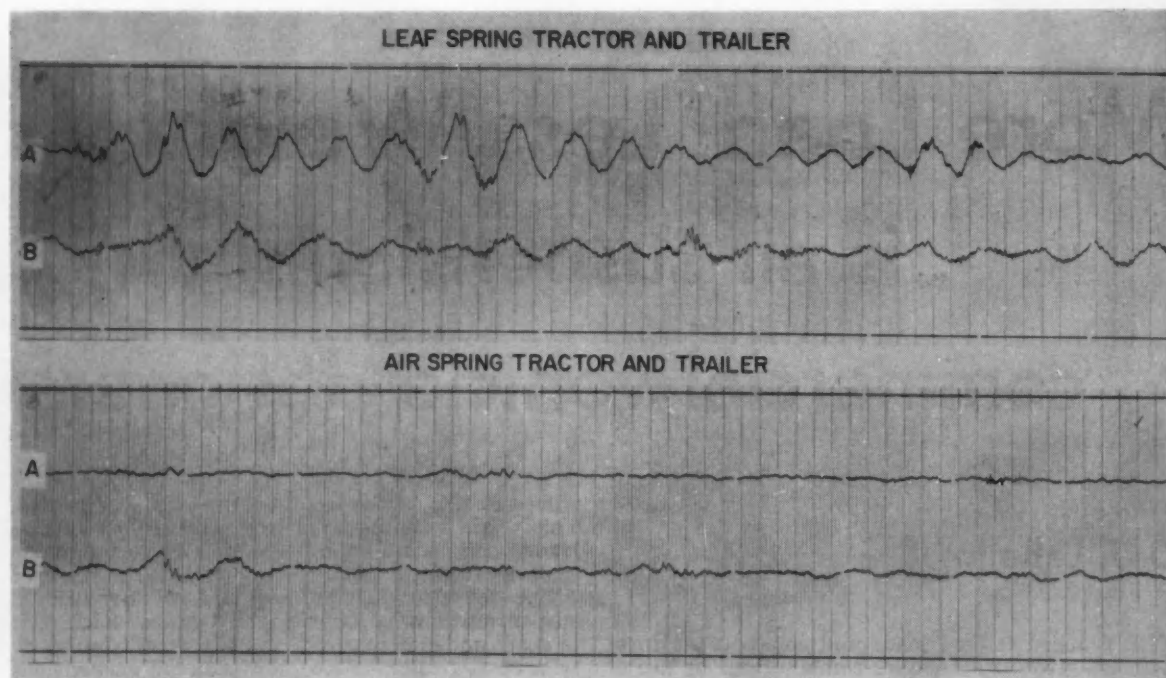


Fig. 1—Records obtained on two vehicles—one with leaf-spring suspension; the other with air-spring suspension—with accelerators mounted on the trailer floor, over the fifth wheel, and over the trailer axles. Note that in the leaf-spring-equipped combination, disturbances in the order of 3-cps are predominant . . . and how the air spring literally irons out this disturbance. (Records taken at 10 mph up 7% grade.)  
 A—Accelerometer over trailer tandem axles.  
 B—Accelerometer over fifth wheel.

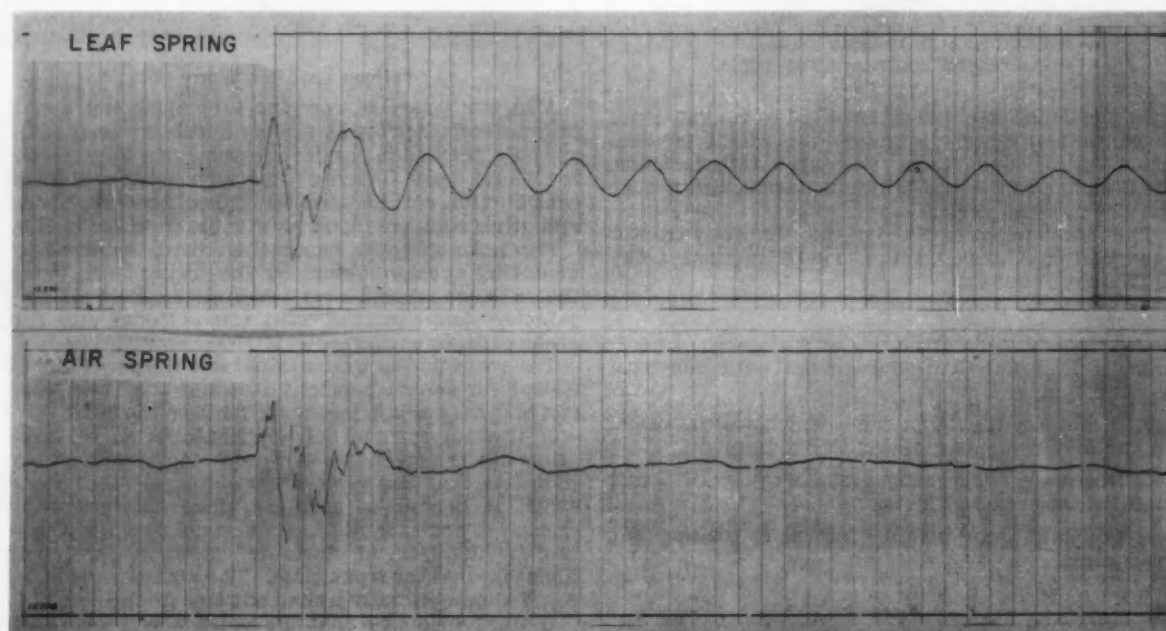


Fig. 2—Results of strain-gage measurements of stress at a critical point in the rear-axle housing of two vehicle combinations—one with leaf-spring, the other with air-spring suspensions. These results also indicate that fatigue life is no longer an important consideration in design if air springs are used.

indicate the relative effects on the structural members of the unsprung portion of the vehicle. The test was run, in this case, by operating the vehicles on a smooth road with a single bump.

Here again, the results indicate that fatigue life need not be an important consideration in the design of a vehicle equipped with air springs.

#### Better Designs Feasible

Assured of these realized benefits, the designer of an air-spring-equipped vehicle can really go to work on weight-saving. If fatigue life is no longer of major importance, he can pay less attention to stress concentration points, for one thing. Also he can take advantage of new methods of construction; he can take advantage of the efficiency of beams of varying depths.

In fact, a new highway vehicle, incorporating all the design advantages made possible by its being equipped with air suspension, might be specifically described by discussing its principal components, as follows:

##### 1. Tires:

Tire diameter, an obstacle to reducing vehicle height, can be reduced only by increasing tire pressures and sidewall thickness, with corresponding increases in tire spring rate. Air suspension (or any frictionless suspension) can overcome the ill-effects of increased tire rate.

##### 2. Wheels and hubs:

Good experience has already been obtained on conventionally sprung vehicles with aluminum wheels and hubs. Existing designs call for metal thicknesses considerably larger than the steel parts they replaced. Another design is called for on vehicles equipped with air suspension.

##### 3. Axle housings:

Use of cast or forged aluminum would be a good start. Careful consideration must be given to the problem of rigidity.

##### 4. Frame:

This important structural member has been, traditionally, a formed steel channel of constant section. Steel has been used because of its high fatigue endurance limit and modulus of rigidity, and channel because of its ability to twist under high torsional deflections without high stress. Tell a designer to forget these limitations and that he can compromise on ground clearance and he'll probably come up with one of the following:

(a) A beam of varying cross-section, deepest where bending moments are maximum, for more efficient use of material.

(b) A truss type of construction, again varying the depth to suit the load.

Table 1—Components Compared

Component	Weight, lb	
	Present Vehicle (Leaf Spring)	New Concept (Air Suspension)
Cab and sheet metal	1,060	500
Frame	750	350
Front suspension and axle	600	500
Rear suspension and axle	1,550	1,150
Brakes and controls	900	900
Engine and clutch	2,000	1,950
Transmission	500	500
Fuel and exhaust system	200	150
Wheels and tires	1,150	900
Electrical system	200	200
Radiator	200	200
100 gallons of fuel	600	600
Coolant	80	80
Tractor equipment	500	400
Ready for road	10,290	8,380

In either case, he can take advantage of manufacturing methods such as welding, since he does not have to be quite so concerned with notch effect at welds or sharp corners at intersections of light-gage sheet metal. He will also take a good look at aluminum construction but must keep rigidity in mind.

##### 5. Miscellaneous brackets:

Hanger brackets, such as fuel tank and engine supports, torque rod anchors, etc., can be made from the light metals without radical increases in material thickness. Design criteria in these parts will be impact strength and rigidity requirements.

##### 6. Cab and sheet metal:

In these components, the best answer to weight saving will be the use of such materials as aluminum, magnesium, and even fiberglass-reinforced plastics.

#### Components Compared

By paying careful attention to design details, the designer should come up with a heavy-duty highway tractor in which the "ready for the road" weight will compare to present-day equipment as shown in Table 1.

To Order Paper No. 241 ...

... on which this article is based, turn to page 5.

Coming . . .

# Torque

Based on paper by

**E. E. Eaton**

Clark Equipment Co.

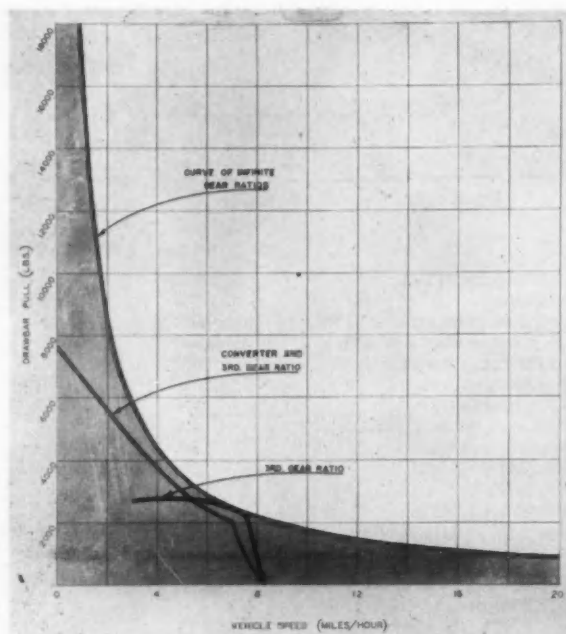


Fig. 1—Performance of a transmission having an infinite number of gear ratios compared with that of the third-speed ratio of a 4-speed transmission. Adding a torque converter to the third-gear ratio increases performance substantially, but leaves a deficiency at the top end of vehicle speed. If a lockup clutch is added to the system, the converter curve will pick up the third-gear curve at its intersection to eliminate the performance deficiency.

**A**N infinitely variable, torque-multiplying transmission—which functions automatically within a design-determined torque range—has many characteristics favorable for use on farm tractors. And experience with torque converters in earthmoving and material handling equipment indicates the possibility of their successful application to farm units.

To determine what a torque converter can do for a farm tractor it is necessary to establish a background for comparison. This background, the target of theoretical perfection, is a transmission having an infinite number of gear ratios. The performance curve of such a transmission, based on a farm tractor of hypothetical specifications, is shown in Fig. 1.

Plotted against this background is a specific transmission ratio, the equivalent of the third-

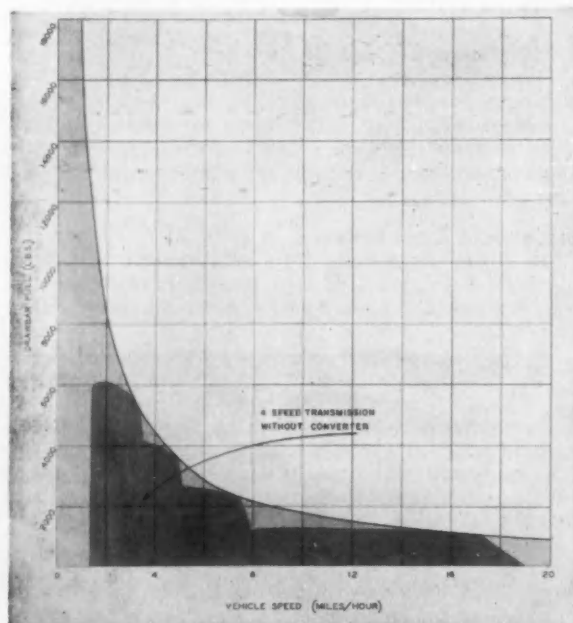


Fig. 2—A 4-speed transmission is a compromise. Certain areas of performance are unattainable with it.

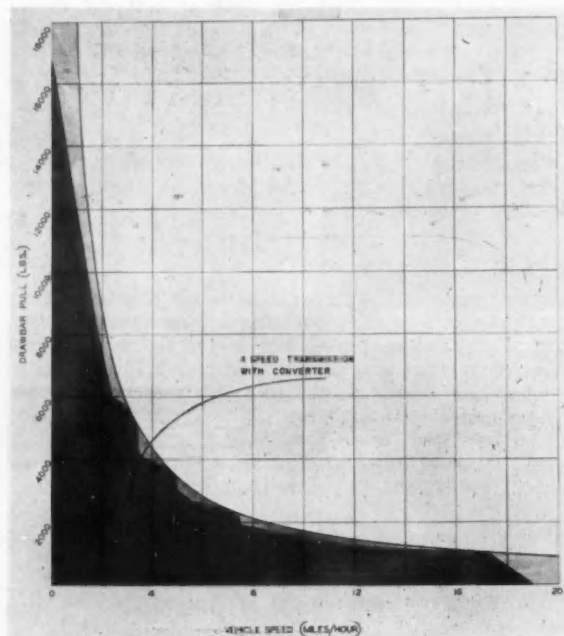


Fig. 3—Add a converter and a lockup clutch to the 4-speed transmission and its performance approaches that of a transmission having an infinite number of gear ratios.

# Converters in Farm Tractors

speed ratio of a 4-speed transmission. This is shown to restrict the vehicle to a relatively small area of performance, but by adding the characteristics of the torque converter to this third-gear ratio the performance area is substantially increased. However, this is achieved at the expense of a decrease in performance for the small area at the top end of the vehicle speed. Now, by adding a lockup clutch to the system, the converter curve will pick up the third-gear curve at its intersection and the performance deficiency is eliminated.

If a complete 4-speed set of transmission gear ratios is plotted against the aforementioned background, as shown in Fig. 2, it becomes apparent that certain areas of possible performance are unattainable. The 4-speed transmission is, therefore, a compromise. But, on the other hand, if to this 4-speed transmission is added a lockup clutch and converter, performance gains are such that the target is nearly covered (Fig. 3). With increasing number of gear ratios combined with the torque converter, the small areas of deficiency diminish to insignificance.

## Pros and Cons of Converters

The torque converter is not a substitute for most existing gear ratios. Certain types of work require the engine to be "geared" to the ground. Other types of sustained work make it desirable to operate in the more efficient geared ratio rather than converter ratio.

The converter is a valuable supplement to gear ratios. It permits smooth and safe starting of vehicle motion under any load or drawbar condition, and makes possible elimination of clutch pedal feathering, shock loading of driveline components and implements. Additional torque multiplication is applied automatically to any gear ratio to meet varying load demand, thus increasing the amount of work which can be done in each gear, reducing gear shifting, and preventing engine slowdown or lugging.

The torque absorption characteristics of the converter permit the engine to run at an efficient speed under severe load conditions. Engine stalling is prevented and the tractor can be held temporarily with a trailing load on an adverse up grade.

Safety is greatly increased with the converter. Instead of controlling the tractor by unpredictable clutch slippage while being exposed to the hazard of engine stalling, or instead of stopping to shift into a lower gear ratio, a micrometer control of

motion is had with the converter by throttle adjustment or brake application without interrupting forward motion, without danger of stalling or backward drifting. Complete and sensitive control of the tractor is possible at all times.

## Converter Means Higher Prices

A converter installation means a higher priced tractor. It means higher fuel consumption and no reduction of engine horsepower. On the plus side will be lower maintenance cost and a greater amount of work performed in a day.

The correct drive for the power take-off still presents a problem. One possibility is to drive the pto shaft from the converter output. This would make available the converter characteristics to pick up the pto inertia load. The pto speed would then be in phase with the vehicle speed. The arrangement would also make possible transmitting engine speed variation to the pto by engagement of the lockup clutch, while at the same time, if required, the transmission could be placed in neutral. By locating the drive for the pto back of the converter, the relation of engine power to converter absorption remains unchanged since there is no bleed-off of power between engine and converter.

A cooler or heat exchanger is generally conceded to be necessary with a converter, but it need not be large or expensive. The absorption characteristics of the converter permit the engine to run at the more efficient cooling fan speeds when the converter is generating the greater amounts of heat.

It is the concept of a converter as an automatic transmission which can be arranged to give constant output speed with input speed and input torque varying to meet fluctuations in load demand, that recommends it for the farm tractor. It permits the use of an output shaft governor to maintain a predetermined ground speed, under varying load demands, for a compatible gear ratio. Thus, changes in ground contour, soil texture, or drawbar pull within reasonable limits will not affect the tractor's working speed.

## Just Around the Corner

The practicability of the converter for the farm tractor is in question. The engineer's slide rule and the fear of price increase are against it. But give the tractor owner a taste of the correctly balanced combination of engine, converter, and transmission and an insatiable appetite will be created.

To Order Paper No. 188 . . .

. . . on which this article is based, turn to page 5.

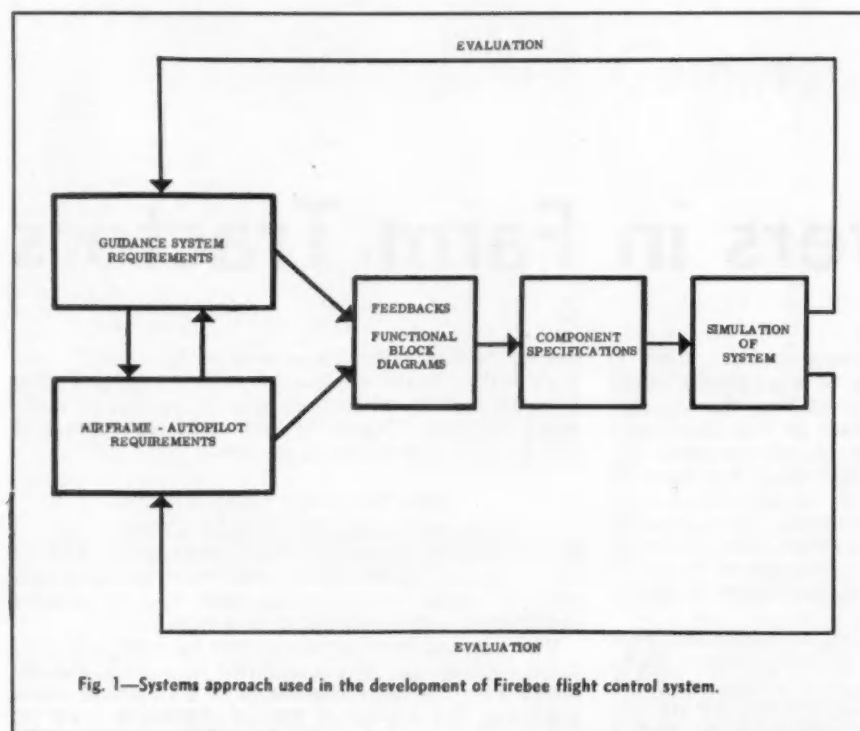


Fig. 1—Systems approach used in the development of Firebee flight control system.

# Simulation — Key to Systems Development

**S**IMULATION is the technique that makes possible the "systems approach" to design. It's the simulator that enables engineers to determine the performance required of each individual component by studying its effect on the performance of the whole system.

The "simulator" is almost always an electronic analog or digital computer. First step in simulation is to formulate the system's behavior as a series of mathematical expressions. Then the analogy is created by forming another, handler-to-manipulate system satisfying these equations, or by programming them on a digital computer.

Simulation has been used in the systems approach to such problems as

- determining the trajectory of a projectile fired from an interceptor required to collide it with an attacker, and
- studying the optimum characteristics for the Firebee's flight control system—and assessing its accuracy, stability, and reliability.

The basic restrictions upon the flight domain of high-speed aircraft trace back to the limitations imposed by the endurance and response capabilities of the pilot. While designers are capable of creating faster and higher flying aircraft, they can not alter the pilot to suit the rapidly changing environment in which these aircraft must operate. However, the pilot can be adapted to function in these environments if the scope of his flying responsibilities remain within his basic limitations. This is accomplished through augmentation of pilot capability with electro-hydro-mechanical systems.

These systems make the pilot and aircraft compatible; the result being an integrated, effective, high-speed aircraft capable of performing its primary mission. To sustain its effectivity, the augmenting system is required to perform the pilot function with the accuracy and response demanded by the aircraft, while simultaneously providing the reliability and stability that is inherent in the pilot.

The design and development of a system embodying these requirements, and its intimate association with pilot and aircraft, stress the necessity for

maximum application of system design engineering. (System design implies that individual component performance is specified by its influence upon desired system performance.)

Various methods are available by use of which system design may be affected. One of the most definitive of these is the application of simulation. Without simulation, the designer must resort to past experience and simplified analysis to predict, for instance, system stability and response. At best, this approach presents a calculated risk when considered in the light of the many nonlinearities and variable characteristics associated with any complex system. In a simulated system these factors may be included, thereby allowing meticulous examination of all facets of the design problem. Equally important are the many economic advantages to be gained from applied simulation, particularly in such areas as flight testing, human performance, and training.

### Simulation Techniques

Simulation may be defined as the representation of a unit or a system's behavior by another unit or system which is analogous or equivalent to the first. The usual common denominator for accomplishing the analog is the formulation of its behavior as a series of mathematical expressions. Once in this form the analog may be created either by generating another unit which also satisfies these equations or by programming the equations directly on a digital or analog computer.

The first method implies creating a specific unit for a specific function. While feasible and sometimes necessary, this method lacks the obvious advantage of versatility inherent with general-purpose type computers.

### Application of Simulation Techniques

During the development of an airborne weapons system there are two phases or areas where simulation may be used. The first is concurrent with the initial design stage. In this area complete system simulation is used; that is, all system components are analogized. This application aids the designer in determining design trends, optimum compromises, parameter limits, and in general assists in the development of a realistic set of component specifications.

The second area starts with the availability of prototype components and ends with successful system flight testing. This area is an application of partial simulation. As prototype components become available they are incorporated as part of the simulation system. The result is a hybrid system composed of prototype components functioning with computer-analogized components. In this stage the dynamic performance of the system may be observed and any component deficiencies rectified prior to production release. Also, during this phase the system and its characteristics are made as analogous to actual in-flight operation as can be achieved within the laboratory. Therefore, maximum flight-test safety is attained, a means of backup and support of the flight-test program realized, and production changes and delays minimized.

While complete simulation offers distinct advantages during initial design, it is considered advantageous, from an economic point of view, to employ partial simulation when many of the system components have passed the initial design stages.

### The Basic Airborne Weapons Problem

Meeting the tactical requirements of a high-speed, all-weather fighter, that is, detection, interception, and destruction of the target, embraces the basic airborne weapons problem. Problem solution requires that the weapon aim point be placed at the lead angle such that when fired, the weapon ballistic trajectory intercepts that of the target.

The vector equation defining the problem is given by:

$$V_a t_f + V_o t_f + d + E = R + V_r t_f$$

Changing this equation to a relative frame of reference, a simpler solution is achieved: since:

$$V_r = V_a + \dot{R}$$

then:

$$E = (R + \dot{R} t_f) - (V_o t_f + d)$$

where:

$V_a$  = Attacker velocity vector

$V_o$  = Projectile average relative velocity vector

$d$  = Projectile gravity drop vector

$V_r$  = Target velocity vector

$t_f$  = Projectile time of flight from release

$E$  = Miss distance vector

$R$  = Present range vector between target and attacker

$\dot{R}$  = Relative velocity vector between target and attacker

The final form represents the basic equation to be solved by the airborne weapons system. The  $(R + \dot{R} t_f)$  term describes the trajectory of the target relative to the attacker. The  $(V_o t_f + d)$  term describes the trajectory of the ballistic weapon relative to the attacker. Subtracting these two quantities gives a miss vector  $E$ . Displaying  $E$  as a steering signal to the pilot allows him to position his aircraft such as

The information presented in this article is based on the following papers:

"Airborne Weapons System Development through Simulation" (Paper No. 205)

by A. H. Noll, Douglas Aircraft Co., Inc.

"Systems Analysis Approach to Firebee Flight Control Systems Development" (Paper No. 203)

by C. D. Corden and H. J. Hansen, Jr.,  
Ryan Aeronautical Co.

To Order Papers Nos. 203 and 205 . . .

on which this article is based, turn to page 5.

## Simulation—

### Key to Systems Development

continued from page 31

to null this signal. He will then have the proper lead angle and may fire his weapon.

### Airborne Weapons System

A system which will solve the basic weapons problem must incorporate not only sufficient detectors and sensors to determine all of the independent parameters present in the weapons equation but also must provide the necessary computational facilities to utilize these data in determining a solution. By considering the specific requirements of these parameters an understanding of the necessary weapons system components may be obtained.

For instance, to determine target trajectory relative to that of the attacker requires the sensing of target position and speed or range rate. This requires radar with range and attack angle tracking capabilities and an antenna drive system. The radar serves as the detector for sight-line range and range rate information and as the detector of angular error between radar sight line and target sight line. The angular error detector together with the antenna drive system and rate gyros form a servo system capable of automatically tracking the target.

To determine the weapon ballistic trajectory relative to the attacker requires the use of flight-data sensors in conjunction with a ballistics-and-flight-data computer. Normally, specific weapon ballistics are predetermined in terms of primary variables of airspeed, relative density, and time of flight. The flight-data sensors are used to measure static pressure, total pressure, stagnation temperature, and angle of attack and skid. Utilizing this information the flight-data computer may determine true airspeed, relative density, and ballistic jump angles resulting from local and remote airflow influences upon the projectile. From information supplied by the flight-data computer, the ballistics computer, by being programmed to the predetermined weapon ballistics, is able to calculate the weapon trajectory. A kinematics section of the computer determines the magnitude of steering error. The difference between ballistic and target trajectories represents the steering error to be displayed to the pilot.

### Systems Approach to Firebee Flight Control

Fig. 1 shows the procedure used for the development of the Firebee drone missile flight control system. Guidance system and airframe-autopilot requirements led to functional block diagrams showing feasible system configurations. Analog computer studies formed the basis for system selection and resulted in component and servo loop specifications. System simulation was then used to evaluate the system with respect to the original requirements.

### Guidance Loop

The most direct approach in determining the requirements of the autopilot and its inputs is to

simulate the entire guidance loop in the laboratory. In this simulation the analog computer replaces the airframe-autopilot combination and the remote control link, while the human operator is used to complete the loop. To improve the simulation, actual autopilot components may be incorporated in the simulation as they become available. From this simulation a realistic evaluation of various airframe-autopilot configurations can be made.

### Autopilot

Detailed knowledge of the dynamic characteristics of the airframe-autopilot block is necessary for simulation of the complete guidance loop. In formulating the requirements for this block, it was necessary to consider the mission objectives of the drone missile. To fulfill the mission requirements, accurate control must be maintained throughout each of the necessary flight modes such as launch, straight and level flight, climbs and dives, and turns. It was also considered desirable to incorporate climbing and diving turns, provide stall prevention, and exploit the aerodynamic performance capabilities of the Firebee.

Investigations were made of various lateral control systems which appeared capable of meeting the guidance loop requirements. The investigations of lateral systems included those based on aircraft heading, roll attitude, roll rate, heading rate, and alleron deflection. Command inputs included beep (ramp), proportional, and step. The most promising systems were those based on: (1) roll attitude with roll-rate stabilization, and (2) heading rate, roll, and roll rate. It was found that these systems gave best guidance control with smallest deviations from the desired course because of their rapid response. With system time lags reduced, the human operator can do an accurate job of controlling the ground track. Fortunately, the roll system with roll-rate stabilization using step commands was one of the simplest systems to mechanize. A vertical gyro, which could also be used as a reference for the longitudinal system, and a roll-rate gyro were the only feedback sensors required for automatic control. The heading-rate system required additional complexity which was not warranted by the guidance loop requirements. A beep type of rudder trim control, operated open-loop by the remote operator, was adequate for lateral trim control. Correction for a heading-rate error, indicated by a curved ground track on the radar plotting board, required only opposite rudder.

To permit the remote operator to devote his attention to lateral control during level flight it was found necessary to incorporate an altitude controller in the longitudinal control system. The use of altitude control alone resulted in an unstable mode except for very low values of altitude control gain. (The term gain defines the ratio of the control surface deflection to the error in the controlled variable. For example, altitude gain is the ratio of elevator deflection to altitude error.) Tight altitude control requirements made it mandatory to provide high altitude gains. The use of rate of climb, airspeed, or pitch angle feedback was found to be satisfactory for stabilization of an accurate altitude-hold mode. Since the use of a vertical gyro

was already contemplated for the roll system, pitch angle feedback information was readily obtained without the use of additional sensing equipment. Climbs and dives could be accomplished by giving either pitch commands or altitude commands. The pitch command system used a simple, readily obtained aneroid-type altitude controller, while the altitude command system required a more complex altitude controller. Availability of equipment dictated the choice of the pitch command system for climb-dive control.

The use of a beep-type pitch command system provided a simple climb-dive control, and resulted in excellent climb performance where telemetered airspeed was available to the remote operator. Where telemetered airspeed was not available, the use of programmed pitch angles resulted in excellent climb-dive performance and provided inherent stall prevention.

From the mutual requirements of the guidance and control loops, the control variables and command inputs for the autopilot were determined. Table 1 is a summary of the required control variables and command inputs.

Additional autopilot requirements were established. These included accuracy requirements for the pitch and roll angles and specifications for minimum damping ratios of the Dutch roll, phugoid, and short-period pitch modes. For example, the allowable roll angle error was specified as  $\pm 2$  deg and the time constant for a change in bank angle was not to exceed 1 sec following a turn command. Zero overshoot in roll angle was also desired when entering a turn.

In addition to the performance requirements for the autopilot, there were certain other general considerations. These included cost, simplicity, reliability, weight, dimensions, power, service life, and environmental requirements.

With the controlled variables, command inputs, and performance requirements outlined, it was possible to consider in detail the dynamic requirements for the servo loops, gyros, altitude controller, and magnitudes of the system gains. The analysis of the airframe-autopilot system was based on the block diagrams indicated in Figs. 2 and 3. In the longitudinal system, the basic controlled variables are pitch angle during the climb-dive mode and altitude during level flight. The errors which exist between the reference and controlled variables provide an actuating signal for the positional elevator control servo loop. The elevator motion produces an airframe response sensed by the vertical gyro and the altitude controller. The resulting pitch angle and altitude errors are fed back to close the loops. During climbs or dives, the altitude sensor is disengaged.

Similarly, for the roll control system, the roll error sensed by the vertical gyro and the roll damping signal from the roll-rate gyro are used to actuate the ailerons through the positional aileron servo loop. In both systems, gain adjustments are provided for setting the loop gains. The rudder trim operates as an open loop and provides a method for cancelling out the heading-rate errors caused by airframe and engine asymmetries.

Damage incurred during repeated parachute recoveries and normal manufacturing tolerances (desirable for low-cost production) result in airframe

Table 1—Summary of Control Variables and Command Inputs for Autopilot

Control Variable	Command Maneuver				
	Climb and Dive	Straight and Level	Turns	Lateral Trim	Airspeed
	Pitch angle	Altitude	Bank angle	Rudder position	Engine speed (rpm)
Command Input	Beep	Beep reset in pitch, on-off altitude control	Step	Beep	Beep

asymmetries. Aerodynamic and thrust moments caused by these asymmetries must be cancelled by equal and opposite moments produced by control surface deflections. For the simple Firebee systems outlined in Figs. 2 and 3 the required control surface deflection can be produced only by an error signal applied to the control surface servo loop. In the roll control system, the rate gyro output is zero during level flight. Any required trim aileron deflection can be produced only by a roll error. Since aileron deflection is directly proportional to the roll error and the roll gain, the required trim aileron will result in a roll error inversely proportional to the roll gain. For this reason high roll gains are very desirable. Similarly, high pitch and altitude gains are necessary in the pitch system to provide trim elevator deflection without introducing excessively large errors in pitch and altitude. To satisfy the error requirements specified for the Firebee it is thus necessary to have high loop gains in both the roll and pitch control axes. The high gain requirements place stringent dynamic requirements on all of the elements contained in the control loops. For example, the loop formed by the airframe, roll-rate gyro, and aileron servo loop must be carefully designed to prevent instability. The requirement for tight control implies that the lags from the positional servo loop and rate gyro be far removed from those of the airframe. For the Firebee, the Dutch roll mode is the highest rigid body mode, and for high-speed flight conditions this frequency is approximately 2 cps. Airframe elastic modes may also be important. The airframe, roll-rate gyro, and aileron servo loop response characteristics must be carefully designed over a wide frequency range to avoid the possibility of autopilot-structural instabilities.

### Autopilot Analysis

For the system analysis of the airframe-autopilot loop, it is desirable to state the dynamic characteristics of the airframe and control system in mathematical terms. The exact equations describing the airframe's motion are inherently complex and nonlinear. The assumption of small disturbances from a steady-state flight condition results in a set of linear airframe differential equations. Fortunately, experience has shown that these linearized equations are satisfactory for representing many aircraft maneuvers. The linearizing assumptions also sim-

## Key to Systems Development

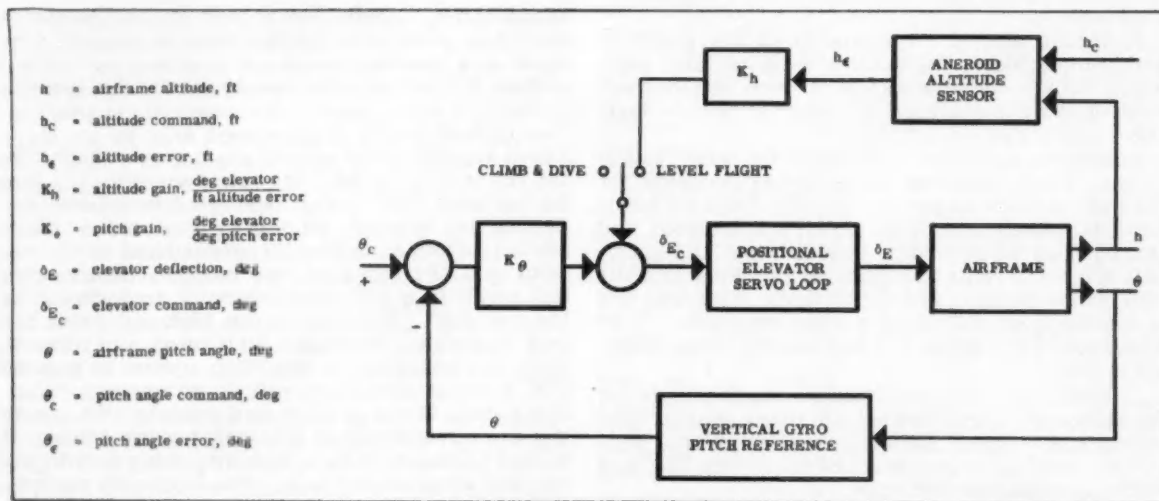
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plify analysis by decoupling the lateral and longitudinal airframe equations.

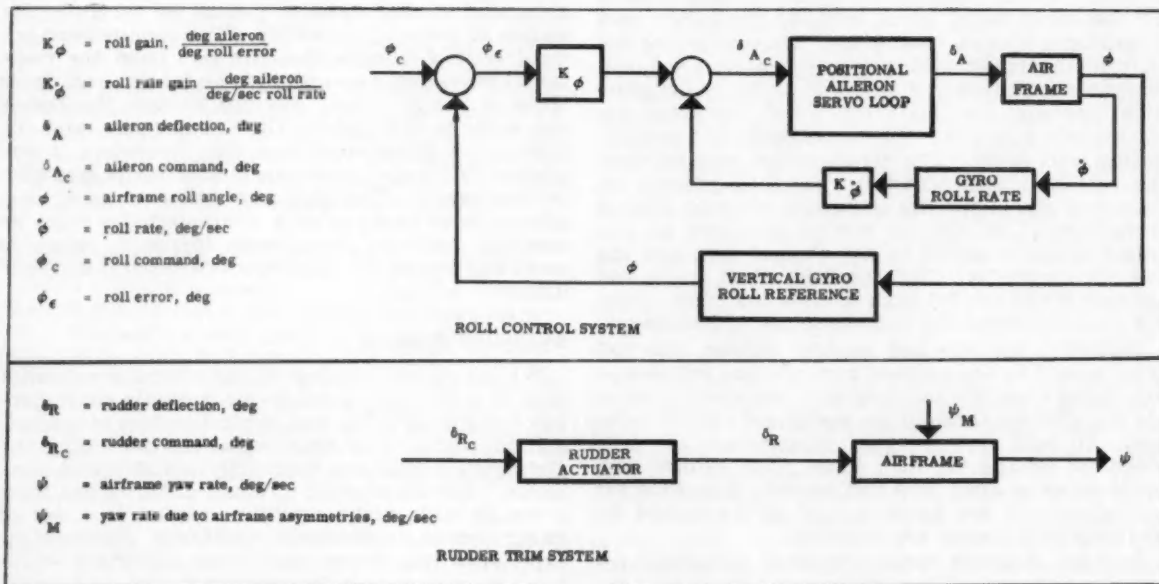
The Firebee systems analysis was based largely on analog computer studies using the linearized airframe equations and simulated elements of the autopilot. Systematic variations in the simulated components characteristics provided a basis for the selection of compatible control elements capable of meeting the system requirements.

To clarify the method of approach used in the autopilot studies, consider the roll control system. Nondimensional aerodynamic coefficients were obtained from a series of wind-tunnel tests on one-sixth and full-scale Firebee models. Six flight conditions representing the maximum variation in airframe response were chosen for investigation. A digital computer was used to obtain the dimensional coefficients of the airframe equations using the nondimensional aerodynamic coefficients, weight, inertia, thrust, and other data related to the flight condition.

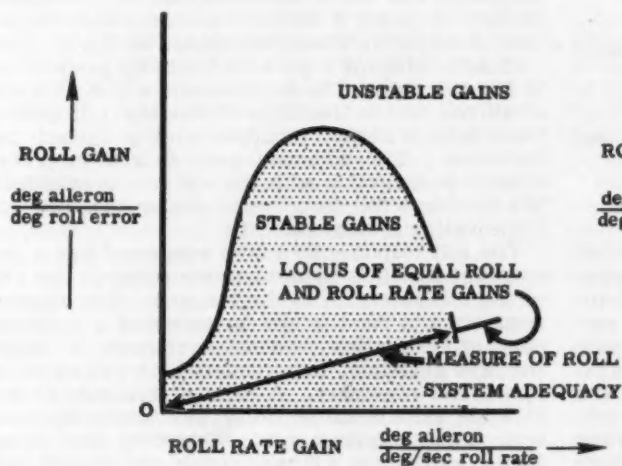
Analytical expressions consistent with available components were also obtained for the servo loops and feedback sensors. To establish the frequency response requirements for the autopilot elements,



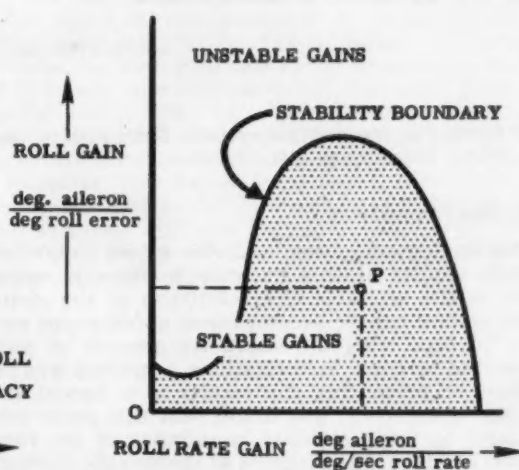
**Fig. 2—Longitudinal control system.**



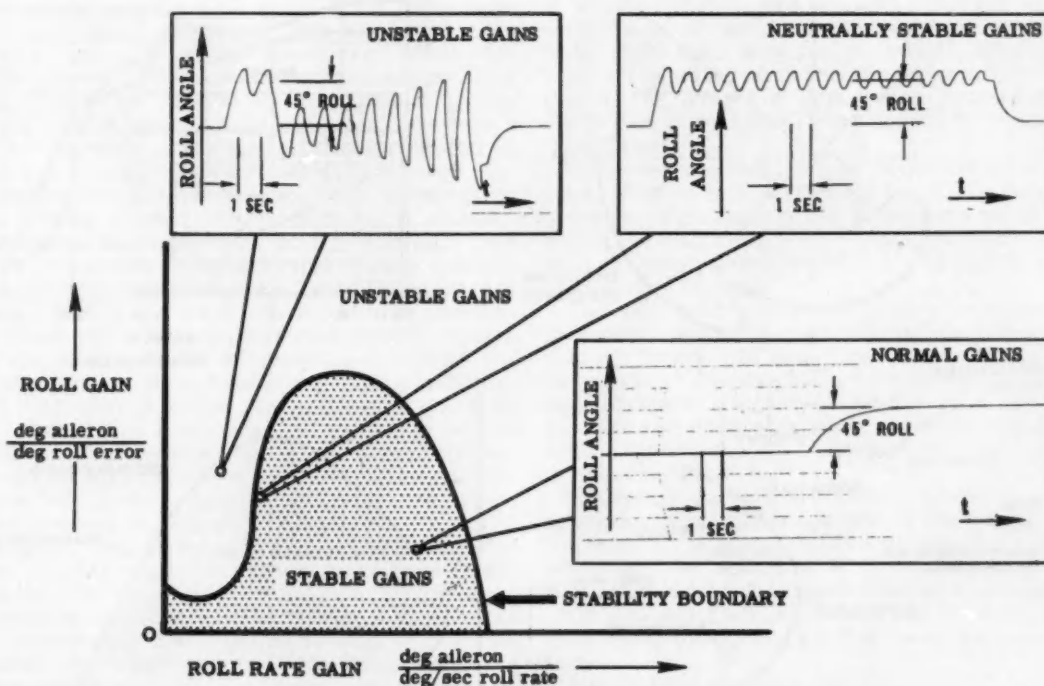
**Fig. 3—Lateral-directional control system.**



(c) MAJOR YARDSTICK USED FOR DETERMINING SYSTEM ADEQUACY



(a) DEFINITION OF ROLL SYSTEM STABILITY BOUNDARY



(b). ROLL RESPONSE TO STEP INPUT FOR VARIOUS GAIN SETTINGS

Fig. 4—Roll system stability boundaries.

# Simulation— Key to Systems Development

continued from page 34

and gains for the control system, both analog and analytical techniques were used.

## Stability Boundaries

The analog computer is ideally suited to control system studies of this nature. Systematic variations in the alterable characteristics of the simulated system can be accomplished quickly and easily. To cope with the enormous amount of data generated by these investigations, a method was required for presenting the results in a logical and concise manner. It was found that this could best be done by using stability boundaries of the form shown in Fig. 4(a). Regions of stable and unstable loop gains are separated by the stability boundary. For example, given values for the roll and roll-rate

gains define a point, P, in the plane. If this point lies within the stability boundary, stable operation is obtained. As the point approaches the stability boundary, less stable operation results, and finally, instability occurs if the point moves outside the stability boundary. This is illustrated in Fig. 4(b).

Steady-state roll errors are inversely proportional to the roll gain. The requirement which exists for small roll errors therefore makes the roll gain an important criterion for determining system performance. The roll-rate gain is also important since in conjunction with the roll gain it establishes the transient roll response of the system, and aids in providing system stability.

The roll response to a step command has a time constant which is approximately equal to the ratio of the roll-rate gain to the roll gain. The response requirements for the system specified a time constant of 1 sec or less, and zero overshoot. To satisfy the zero overshoot requirement high roll-rate gain was found necessary. A ratio of roll-rate to roll-attitude gain equal to unity was most compatible with these requirements. Therefore one of the major yardsticks for measuring roll-system adequacy became the distance between the origin and stability boundary measured along the straight line

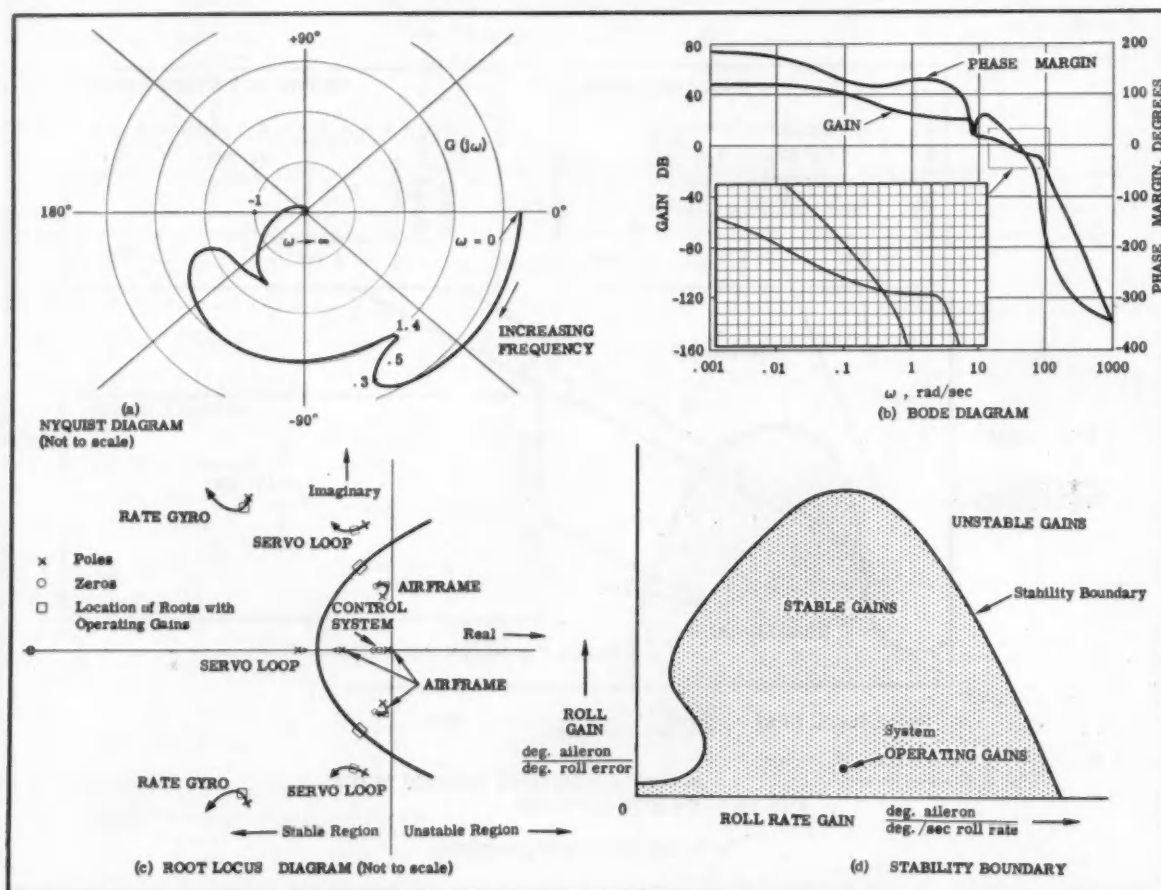


Fig. 5—Application of linear analysis methods to roll-control system.

defined by equal roll and roll-rate gains. This is shown in Fig. 4(c).

The stability boundaries for the roll system were obtained by adjusting the roll and roll-rate gains on the analog computer until a point of neutral stability was reached. A locus of such points constituting a stability boundary can be obtained in approximately 20 min. Using the system-adequacy yardstick, systematic variations in the alterable characteristics of the control-system elements for the required flight conditions produced optimum autopilot system specifications. Additional specifications were made regarding tolerable amounts of nonlinear effects such as hysteresis, threshold, friction, torque and velocity limiting.

It was found that one set of roll-system gains gave the required quality of control and stability for all the investigated flight conditions. Additional system complexity was thereby avoided since no requirement existed in flight for gain changes in the control system. Characteristics specified on the basis of the analog computer studies included frequency response, maximum velocities, and maximum torque requirements for the aileron servo loop; and frequency response, threshold, and roll-rate input requirements for the roll-rate gyro.

In addition to the analog computer studies, Bode, Nyquist, and root locus methods of analysis were used. These studies provided an independent check on the analog computer results and gave invaluable insight into the control problems. Fig. 5 presents the results of a roll-system study for a high-speed low-altitude flight condition. Figs. 5(a) and 5(b) show the open-loop frequency-response characteristics of the roll control system for normal operating gains. The phase margin at unity gain is 30 deg and the gain margin is 6 db. Fig. 5(c) shows the locus of the roots of the characteristic equation as the roll system gains are increased from zero. Fig. 5(d) shows the stability boundary and the location of the operating gains used for Figs. 5(a, b, and c).

Aeroelastic characteristics of the airframe may sometimes have an important effect on the stability of the airframe-autopilot loop. Since the Firebee is relatively stiff, it has coupled modes at high frequencies where the attenuation of the control system precludes the likelihood of autopilot-structural instability. For example, the lowest coupled body torsional frequency is 66 cps (415 rad/sec.) Fig. 5(b) shows that at this frequency, the open-loop control system attenuation is 90 db. Since aeroelastic effects did not appear to be critical, no rigorous investigation was made to include the additional autopilot-structural degrees of freedom.

Machine methods are available to aid system analysis. Digital computer routines have been established for determining the coefficients for the characteristic equations of the airframe. The roots of these equations can also be determined by machine methods. Programs are available for determining the frequency response of a given element from its time constants, natural frequencies, and damping ratios. The transient response of a linear system may also be found by using an existing routine.

### Physical Simulation

Autopilot components were selected on the basis of the analog studies with additional consideration

given to such factors as cost, reliability, and availability. As the components became available they were incorporated in the closed-loop simulation. By the time final simulation of the autopilot was made, all of the components of the autopilot except the sensors were used. The airframe equations of motion together with the measured characteristics of the gyros and altitude controller were simulated by the analog computer. The control surfaces were spring-loaded to simulate the aerodynamic hinge moments encountered in flight.

Stability boundaries were again determined to verify the system performance prior to flight test and to obtain optimum system adjustments. Final simulation indicated that the autopilot system requirements would be met.

## Snorkels and Sulphur —

... hurt diesel engines. Eight tests show oil additives may help submarine operation.

**S**NORKEL-breathing diesel engines show marked wear, corrosion, and deposits when run on high sulfur fuels. To pin down the troubles and find solutions, eight tests were run on a GMC-278A engine. They are reported on in CRC Report 298, "Investigation of the Effects of Fuel Sulfur Content on the GMC-278A Submarine Diesel Engine Under Snorkel Conditions."

Underwater operation was simulated by a 6 psig back pressure and a minus 2 in. of Hg gage inlet pressure. Eight runs of 500 hr were made using fuel sulfur contents from 0.10 to 0.86%. Lubricating oils with different amounts and types of additives were used during the tests.

The high sulfur fuels and snorkel operation were responsible for (1) the corrosion of chrome plate on cylinder liners, (2) high ring and liner wear, and (3) excessive deposits when Navy Specification 14-0-13A lubricants were used. Sulfur takes the blame for ring and liner wear while snorkel operation accounts for the deposits. The corrosion is a product of both conditions.

Increasing the additive content of the oil reduced all three complaints and improved the cleanliness of the engine. However, valve seat material compatibility with oil additives is questioned since valve burning occurred during one high oil additive run.

Cooling water temperature to valves was increased from 143 to the normal 166 F without appreciable effect.

Future tests will explore:

- Water jacket temperatures above 166 F.
  - Different lubricating oil combinations.
  - Different exhaust valve metallurgy construction.
- CRC Report 298 contains 52 pages including figures, graphs, and tables.

▲ To Order CRC-298 . . .

... on which this article is based, turn to page 5.

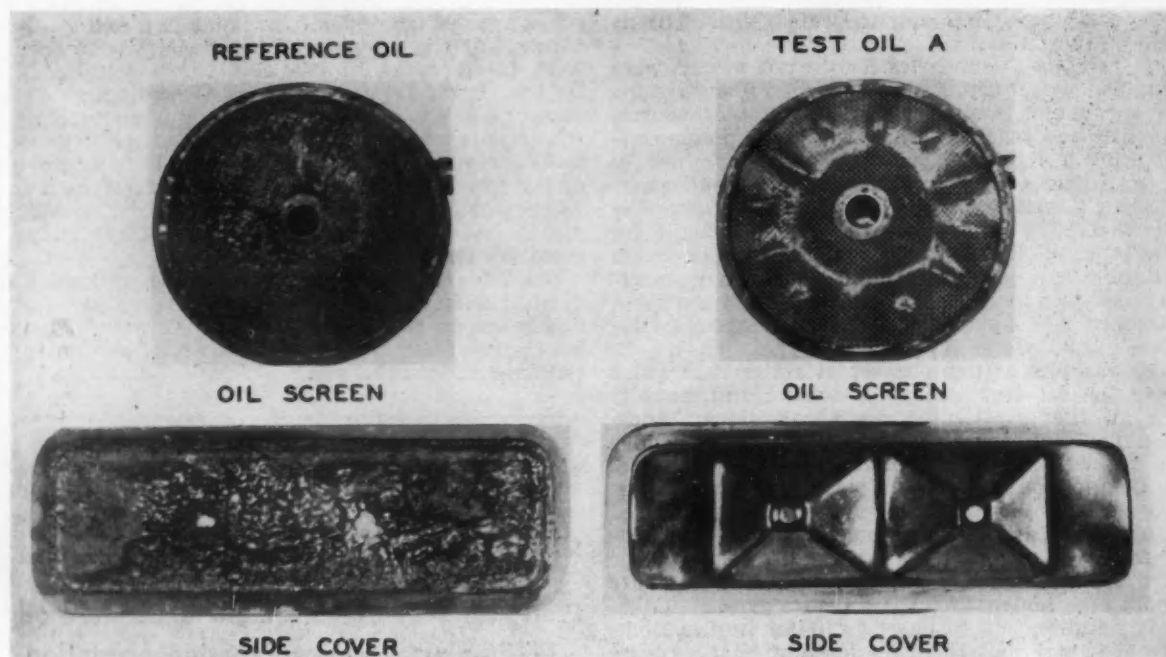


Fig. 1—Test oil A—a polymeric detergent multigrade oil—gave greatly reduced engine sludge in 30,000-mile tests in a taxicab fleet.

# New nonmetallic oil additive reduces engine deposits ...

also provides some increase in gasoline mileage, power output, cranking speed, and octane requirement.

Based on paper by

**J. A. Miller and C. K. Parker, Jr.**

California Research Corp.

**P**OLYMERIC detergents are a new type of non-metallic additive capable of reducing drastically the deposit-forming tendencies of multigrade oils under start-stop conditions. They also provide modest improvements in:

- Gasoline mileage.
- Power output.
- Cranking speed.
- Octane requirement increase.

Multigrade oils containing this additive appear, at the same time, to be at least as effective as conventionally compounded ones in maintaining low high-temperature deposits and in reducing corrosive wear, e-p wear, and rubbing bearing wear.

## Reduced Start-Stop Deposits

The best evidence of the reduction in deposits that can be achieved through the use of a polymeric detergent oil in city traffic driving service is illustrated by the results of the taxicab tests shown in Table 1. Fig. 1 shows even more dramatically how effective the new oil was in reducing deposits.

These data were obtained from two fleets operating in the San Francisco Bay area using identical

engines, gasolines, and lubricating oils. The reference oil was of Supplement 1 level of compounding. Test oil A was a 10W-30 oil containing a polymeric detergent and a suitable level of zinc dithiophosphate. Physical properties of the oil are given in Table 2. All the engines were new or rebuilt to factory specifications at the start of the test.

The difference in deposit levels with the reference oil for the two fleets, as shown in Table 1, is due to differences in operation and maintenance. Fleet A, obviously, was much more severe in regard to deposits than Fleet B. Yet under both conditions the test oil controlled the deposits.

It is possible to have even more severe sludge conditions than those illustrated here. Under such conditions the deposit level with both oils would be higher. But the same relative reduction in deposits would exist between the test and the reference oils.

### Reduced Engine Friction

Polymeric detergent oils undergo the same beneficial temporary gain in fluidity (lessening of viscosity) with high rates of shear as do oils containing nondetergent thickeners of the same general chemical type. It is the temporary gain in fluidity with high shear that is responsible for the reduction in engine friction, resulting in improved gasoline mileage and better power output. A slight increase in cranking speed also results from the temporary improvement in viscosity with shear, but the major cranking gain is due to the high viscosity index.

The effect of shear rate on the viscosity of thickened and unthickened oils is illustrated in Fig. 2. (Shear rate is the velocity in the oil film divided by the film thickness and has the units of reciprocal seconds.) As may be noted in Fig. 2, shear rate has no effect on the viscosity of a neutral oil or on the viscosity of the same neutral oil thickened to a higher viscosity with heavy lubricating oil stocks. However, when the neutral is thickened to the same higher viscosity with a polymer, the viscosity is reduced as shear rate increases, as illustrated by the curved line. This reduction in viscosity ceases as soon as the shearing forces are removed. Thus, in an engine, a polymer-thickened oil of 65 SSU at 210 F does not have a constant viscosity in all operating parts. In the example chosen, the oil in the main bearings has the viscosity of an SAE 20 oil, while on the cylinder walls and in the rod bearings, where higher shear rates exist, the viscosity approaches that of the base oil. Thus, the engine friction is reduced. In areas of low shear, however, such as behind the piston rings, the viscosity of the thickened oil is the same as that of the conventional oil. Therefore, the amount of oil pumped by the piston rings will be the same as that of the conventional oil. Thus, both the conventional oil and the thickened oil will give the same oil mileage, provided the volatility of the two lubricants is approximately equal.

The first example of the effect of shear on oil viscosity is observed under cranking conditions. This is illustrated in Fig. 3, which compares the measured cranking speeds obtained with test oil A to the calculated cranking speeds for test oil A and the base oil used in test oil A. These data were ob-

Table 1—Control of Sludge in Engines in City Traffic Driving (Taxicab Engines—30,000 Miles)

	Fleet A		Fleet B	
	Supplement 1 Level Reference Oil	Test Oil A	Supplement 1 Level Reference Oil	Test Oil A
Number of Test Engines	4	4	3	3
Average Oil Ring Clogging,				
No. 3 Ring, %	50	0	25	0
Average Oil Ring Clogging,				
No. 4 Ring, %	20	0	20	0
Average Oil Screen				
Clogging, %	50	0	15	0
Average Side Cover Plate				
Sludge	Heavy	Very light	Medium	Very light

Table 2—Physical Properties of Test Oil A

Gravity, deg API	29.5
Flash Point, F	420
Viscosity at 0 F, SSU (extrapolated)	9800
Viscosity at 100 F, SSU	345
Viscosity at 210 F, SSU	68.8
Viscosity Index	142
ASTM Pour Point, F	-40

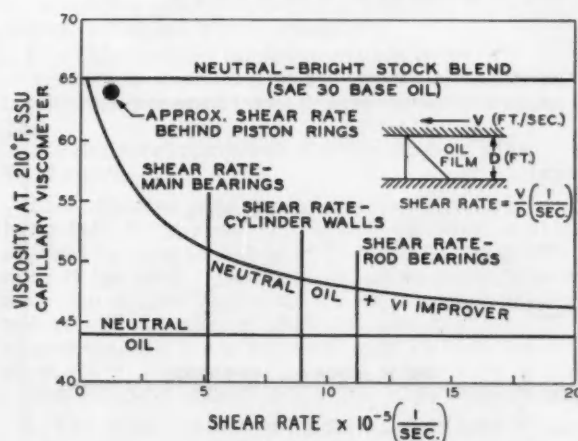


Fig. 2—Viscosity was reduced as shear rate of neutral oil plus V.I. improver was increased. It remained constant for neutral oil. Laminar flow.

## New nonmetallic oil additive reduces engine deposits . . .

continued from page 39

tained by cranking a laboratory engine in a cold room, all components of the engine, including the battery, being at the same temperature. The effect of viscosity on cranking speed was first determined by measuring the cranking speed at various temperatures with conventional oils of known viscosity. Thus, a calibration curve of cranking speed as a function of extrapolated viscosity was established. From this calibration it is possible to calculate the cranking speed at any given temperature for any

unthickened oil in which the wax structure is fragile. This is also true of thickened oils, provided the extrapolated viscosity of thickened oil is not less than that of the base oil used in the thickened oil. These calculations were made for the base oil used in test oil A and for test oil A, as shown in Fig. 3. The better measured cranking speed for test oil A compared to the calculated speed is due to the temporary gain in fluidity with shear.

The second example of improved performance due to temporary change in viscosity at high rates of shear is shown in Fig. 4. This figure shows the relationship between lubricating oil viscosity and relative gasoline mileage. These data were obtained in a laboratory engine under steady running conditions simulating 1000 miles of highway driving (2500 rpm, road load, 220 F oil temperature, 180 F jacket temperature). The curve was obtained with conventional single-grade oils of the viscosity shown. It

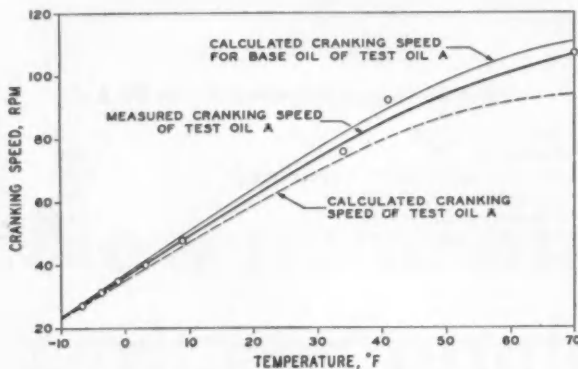


Fig. 3—Measured cranking speed with test oil A was better than calculated, due to temporary gain in fluidity with shear.

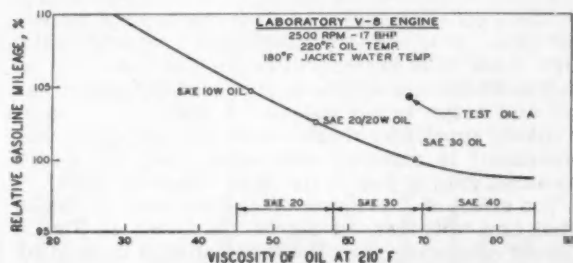


Fig. 4—Temporary change in viscosity at high rates of shear also improved gasoline mileage when test oil A was used (laboratory engine run under simulated highway operation).

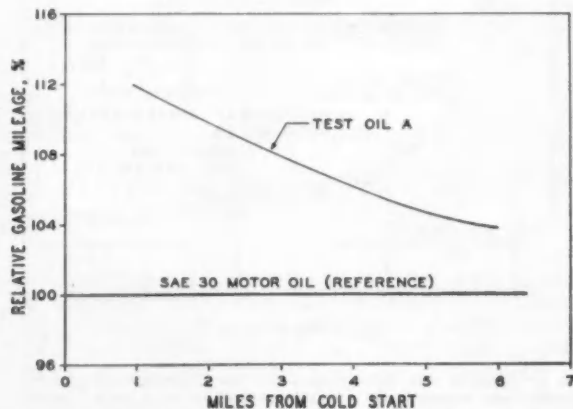


Fig. 5—Test oil A gave better gasoline mileage than SAE 30 oil during warmup of 1957 passenger car on road test.

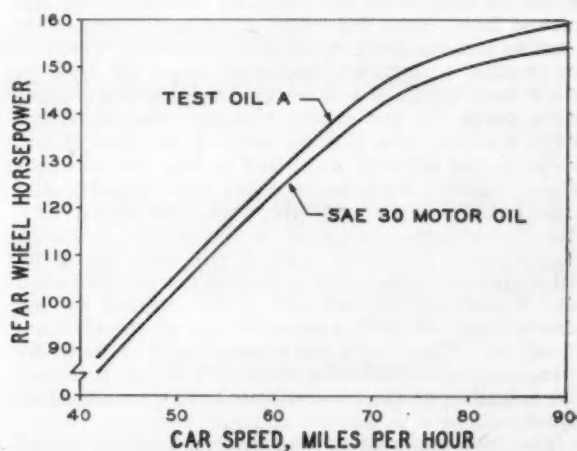


Fig. 6—Rear wheel horsepower was higher with test oil A than with conventional oil (1956 passenger car operated at wide-open throttle on chassis dynamometer).

may be noted that an improvement in gasoline mileage of about 2½% is achieved for each 10 SSU reduction of viscosity at 210 F. It may also be noted that the gasoline mileage obtained with the polymeric detergent oil, which had a viscosity of about 69 SSU at 210 F, was the same as that obtained with the conventional SAE 10W motor oil. This is because the engine friction with the polymeric detergent oil approached that of the 10W oil under high shear. The 5% improvement shown for the multigrade oil is typical for this type of operation. Under warmup conditions where viscous friction is higher, a much greater improvement in gasoline mileage will be achieved with a multigrade oil compared to a single-grade oil of the same viscosity at 210 F. Fig. 5 shows the effect of lubricating oil viscosity on gasoline mileage during warmup obtained in a 1957 passenger car on the road. The performance of the polymeric detergent oil was compared to that of an SAE 30 oil. It may be noted that an improvement of 12% in gasoline mileage was effected during the first mile of operation compared to the 30 grade oil. After six miles of operation the multigrade oil showed approximately 4% better gasoline mileage than the SAE 30 reference oil. This is in good agreement with the improvement in gasoline mileage shown in Fig. 4 for steady running conditions. Similar tests at lower temperatures have shown improvements in gasoline mileage as high as 20% during the first mile of operation.

The use of multigrade oil in place of conventional single-grade oil will also improve power output. Fig. 6 shows the improvement in rear wheel horsepower achieved when the polymeric detergent oil was used in place of a conventional SAE 30 oil. These data were obtained in a 1956 passenger car on a chassis dynamometer under full-throttle conditions. In this test an improvement of about 3% was achieved.

#### Octane Requirement Increase

Conventionally compounded multigrade oils can reduce octane requirement increase by 3-4 numbers, compared with conventional single-grade oils. This reduction is due primarily to the lack of heavy residual oil stocks in these lubricants and occurs only under light-load, start-stop driving, where octane requirement increase is a maximum (12 or more octane numbers). Under high-load, high-speed operation, octane requirement increase with conventional gasolines and oils is low (5-8, or less). Under these conditions no measureable effect from the use of the multigrade oils will be observed.

The use of the polymeric detergent oil in place of a conventional multigrade oil will effect a further reduction of octane requirement increase of several numbers under the light-load conditions. This is because this oil does not contain the calcium or barium additives common to conventional multigrade oils. While this reduction will be observed in many engines that operate under light load, where octane requirement increase is high, the beneficial effects will not be so apparent in some modern high compression ratio engines, where clean octane requirements are very high and the octane increase is only 3-5 numbers.

▲ To Order Paper No. 160 . . .

... on which this article is based, turn to page 5.

## Ice on the Wings . . .

... causes airfoil drag coefficient changes.

A formula for calculating these changes from regular design and performance parameters has been developed by NACA.

Based on paper by

Vernon H. Gray,

Lewis Flight-Propulsion Laboratory, NACA

**A**IRFOIL drag coefficient changes caused by icing can be predicted from icing and flight conditions by means of the following formula:

$$\Delta C_d = \left[ 8.7 \times 10^{-6} \frac{\tau V_o}{c} \sqrt{w \beta_m} (32 - t_o)^{0.3} \right] \left[ 1 + 6 \left\{ (1 + 2.52 r^{0.1} \sin^4 12\alpha) \sin^2 \left[ 543 \sqrt{w} \sqrt[3]{\frac{\bar{E}_m}{32 - t_o}} \right] - 81 + 65.3 \left( \frac{1}{1.35^{a_1}} - \frac{1}{1.35^a} \right) \right\} - \frac{0.17}{r} \sin^4 11\alpha \right]$$

where:

$\Delta C_d$  = Change in airfoil section drag coefficient due to addition of ice

$\tau$  = Icing time, min

$V_o$  = Free-stream velocity, mph

$c$  = Airfoil chord length, in.

$w$  = Liquid water content of cloud, g per cu m

$\beta_m$  = Maximum local droplet impingement efficiency

$t_o$  = Free-stream total air temperature, F

$\alpha$  = Airfoil geometric angle of attack

(uncorrected for tunnel walls), deg

$\bar{E}_m$  = Total droplet impingement efficiency

$a_1$  = Airfoil geometric angle of attack at which ice deposit is formed (uncorrected for tunnel walls), deg

$r$  = Radius of curvature of airfoil leading edge, % of chord.

This equation covers available aerodynamic and icing data for airfoils (up to 15% thickness ratio) exposed to icing conditions in the NACA icing tunnel. It has been found to correlate reasonably well with the actual measured values, considering the nature and difficulty of obtaining aerodynamic, impingement, and meteorological data in icing conditions.

The equation should prove useful in estimating:

1. The type and size of ice formations that would result from any specific icing encounter.
2. The aerodynamic penalties that would result from an encounter.
3. Icing effects for flight performance studies.

▲ To Order Paper No. 225 . . .

... on which this article is based, turn to page 5.

# New Uniflow 2-Stroke Diesel

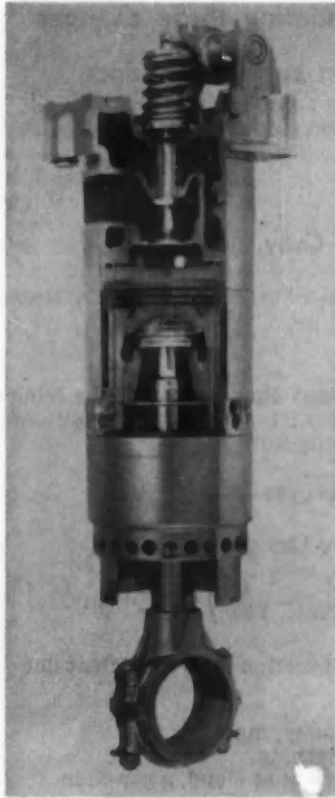


Fig. 1—Cutaway showing ball-joint connection between piston and connecting rod.

Based on paper by

**M. W. Paquette**

Harnischfeger Corp.

**T**HE P&H uniflow-scavenged 2-stroke diesel engine displays a number of interesting design features. Among them are the following:

1. A ball-joint connection between piston and connecting rod in place of the old tried-and-true wristpin.
2. Use of aluminum as the basic foundry metal instead of the usual cast iron.
3. A single centrally located exhaust valve and round ports.
4. Cylinder head and liner assembly redesigned to improve cooling.

## Features . . .

- Ball-joint connection in place of wristpin
- Extensive use of aluminum
- Single exhaust valve and round ports
- Cylinder head and liner of new design
- Elimination of combustion seal gasket

5. Elimination of combustion seal gasket between liner and cylinder head.

### Ball-Joint Connection

Recently our company took a radical step away from the old tried-and-true wristpin type of connection between the piston and connecting rod. It was decided to try the old engineering dream of a ball-joint connection. Since in a 2-stroke engine the piston is always under load, it seemed as if the unit could be successfully engineered. This is borne out by the application of relatively low tensile strength fastenings at the lower end of the connecting rod on other 2-stroke engines. Preliminary tests run on hand-fitted units proved satisfactory. The ball joint, or mushroom as we call it, underwent various development changes, which were largely required by the shop in order to make the unit easier to machine.

Fig. 1 is a cutaway showing the new mushroom setup. There is a plate under the piston crown; to give the proper heat flow through the piston. Below the heat dam is an aluminum bearing cup.

Next comes the assembly of the mushroom: the tubular rod, the lower bearing retainer, and the lower rod end. These parts are pre-assembled and brazed on a thermonic unit. Pull tests have shown that approximately 70,000 lb can be applied without damage. After insertion of the mushroom rod, the bearing retainer is slipped into place and the entire unit retained by a beveled snap ring.

The following advantages are obtained from this design:

1. Approximately 250% more bearing area is obtained on the mushroom than on the conventional wristpin.

2. Controlled heat flow most conducive to good piston and piston-ring operation can be obtained.

3. A freely floating piston capable of rotational movement within the cylinder liner equalizes the wear pattern on both the piston and the liner.

4. Accuracy of the centerline of the crankcase bore with respect to the crankshaft axis is not as critical with this freely floating piston as with the wristpin type of connection.

Tests show that with bmep's as high as 167 the upper aluminum bearing shows no signs of heat or wear. The mushroom becomes highly polished and takes on the appearance of a mirror. The wear rates on piston, liner, and rings have become an absolute minimum.

A 7000-hr test recently completed on a 3-cyl engine using the mushroom piston in one position had a total liner wear at the worst point of 0.0034 in. per 7000 hr of operation or 0.0005 in. per 1000 hr. This engine was running at a bmep of 84 psi at 1800 rpm. Top ring wear gap increase averaged 0.00125 in. per 100 hr and second ring wear gap increase averaged 0.00012 in. per 100 hr. This low wear appears to be due to the rotational movement of the piston in the mushroom connecting-rod piston assembly, the use of straight and round liners, and the excellent piston cooling made possible by the fit of the piston in the liner.

Similar tests with an engine having the old wristpin type of setup gave an average wear rate of 0.001 in. per 1000 hr, with more wear, of course, on the thrust side of the liner than on the antithrust side.

The question then arises—what is the lube oil consumption? The oil consumption is normally maintained at around 3000–4000 bhp-hr per gal. The 3-cyl engine ran during the first 500 hr of operation with an oil consumption of between 12,300 and 14,600 bhp-hr per gal, as shown in Fig. 2. This is equivalent to 0.00062–0.00049 lb per bhp-hr.

#### Use of Aluminum

The crankcase is cast in high tensile aluminum alloy 356-T 71. Other major engine components such as the piston, oil pan, valve cover, water manifold, cam pocket cover, flywheel housing, and the front cover are also made of aluminum.

Figs. 3 and 4 are the keys to some of the reasons why aluminum was selected as the basic foundry metal instead of the usual cast iron.

The ratio of specific gravities (2.61) is the determining factor in the cost per cubic foot, the freight cost, and in material handling costs. Basically, this means that aluminum can be 2.61 times more expensive than cast iron without increasing the cost per piece. Aluminum costs currently are: 67¢ to \$1.50 per lb, while the cost of cast iron is between 9¢ and 48¢ per lb.

Reducing the cost of aluminum by the rate of specific weights (2.61) results in a comparative cost per piece of 0.257–0.575. As shown in Fig. 4, there is a large overlap in price between aluminum and cast iron, even though the relative cost of aluminum is higher. This higher price is offset by the reduced cost of freight and by the increased machinability and longer tool life, and the consequent reduction in labor burden. In the final analysis the use of aluminum is economically feasible and highly practical. Most important, of course, is the fact that it

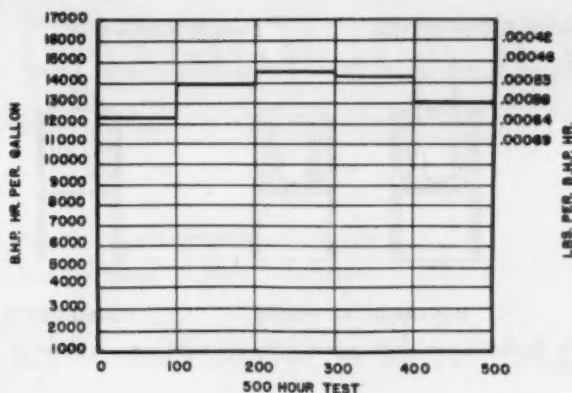


Fig. 2—Lubricating oil consumption was unusually low in 3-cyl engine using new ball-joint connection (84-psi bmep, 1800 rpm).

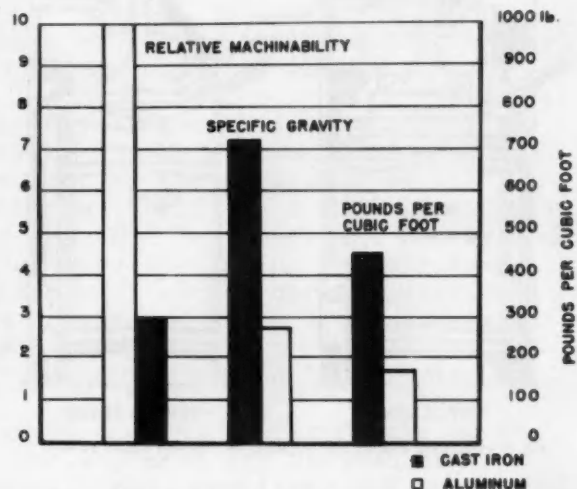


Fig. 3—High relative machinability, low specific gravity and pounds per cubic foot make aluminum a very desirable metal for use in engines.

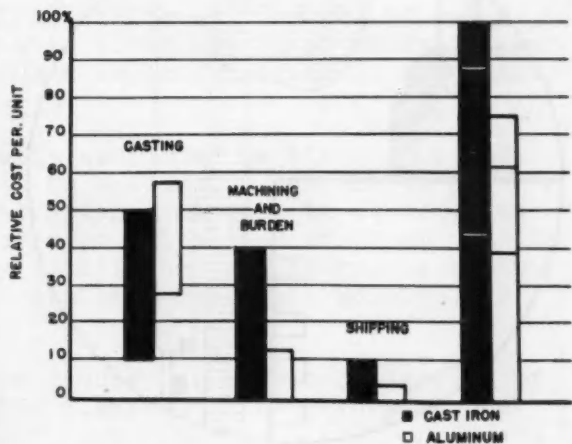
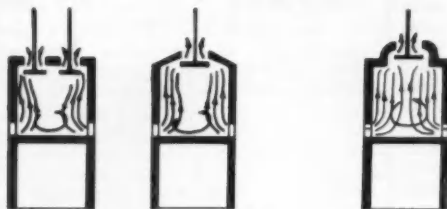


Fig. 4—There is a large overlap in price between aluminum and cast iron, even though relative cost of aluminum is higher.

#### MULTIPLE EXH. VALVES

#### SINGLE EXH. VALVE



#### RECTANGULAR PORTS

#### ROUND PORTS

Fig. 5—Engine uses single exhaust valve and round ports, as shown at right.

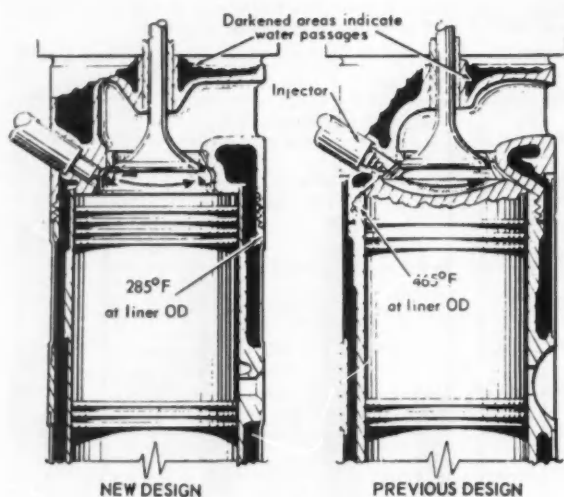


Fig. 6—Improved cooling was obtained by redesign shown at left.

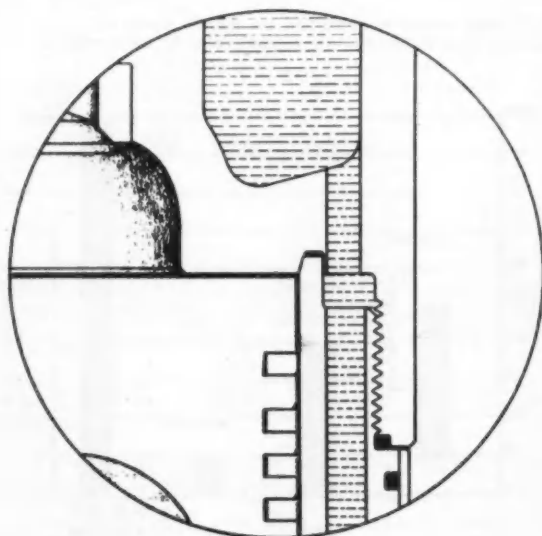


Fig. 7—Head and liner design incorporates wedge liner seal and cooling arrangement.

results in a lightweight end product which is in line with the demands of today's market.

#### Exhaust Valve and Inlet Ports

Uniflow scavenging must basically be accomplished by valves in the head with ported liners. The problem is usually to obtain a large enough valve opening with a minimum of parts. Numerous small valves can give sufficient flow area but, as indicated in Fig. 5 at the left, contribute certain difficulties to good scavenging. A large centrally located valve, on the other hand, has certain inherently good characteristics with respect to the same problem, as is shown at the right of Fig. 5. The major problem with one valve usually resolves itself into obtaining the necessary flow area and still maintaining valve gear train reliability.

The original P&H scavenging system is shown in the center of Fig. 5. Rectangular porting manufactured to induce a partial swirl was used, but very little swirl was actually obtained. So the combustion chamber was changed to the open Dutch cheese type, with no changes in the valve train mechanism. Two rows of holes were used for the inlet porting. The upper row of holes was drilled perpendicularly to the cylinder centerline but at 37½ deg to give a circumferential direction to the air. The lower row of holes was also drilled perpendicularly to the centerline of the engine. This row of holes was drilled radially to allow the air to sweep out the exhaust gases in the center of the liners.

#### Cylinder Head and Liner Assembly

To improve cooling the cylinder head and liner assembly, which are screwed together, was redesigned. At the right of Fig. 6 is the former design. This shows the threads at the inside of the cooling passage. Since heat transfer through threads must be relatively poor due to the difficulties of getting perfect metal-to-metal contact on the threads, the cylinder head and liner assembly was redesigned, as shown at the left. The threads were moved outward diametrically and water passages incorporated between the threads and the liner bore to bring the coolant closer to the liner ID. At the same time the liner material was changed from alloy steel to an alloy cast iron. Removable water jackets were then used with O-ring seals. These jackets and O-rings replaced the jackets that were formerly brazed to the liners.

#### Combustion Seal Gasket Eliminated

The combustion seal gasket between liner and cylinder head, which is always a possible source of trouble in any kind of combustion engine, was found to be an unnecessary item. Development and precision machining produced a metal-to-metal seal. By means of a groove in the cylinder head and a cylindrical projection on the top of the liner—both beveled on the inner diameter—we were able to obtain a pressure-tight seal between liner and head with no liner distortion. This arrangement is shown in Fig. 7.

To Order Paper No. 246 . . .

. . . on which this article is based, turn to page 5.



## SAE LOOKS OVERSEAS

3 AIR FRANCE  
CARAVELLES  
TO BE IN  
SERVICE LATE  
IN 1958

ALGIERS TO  
PARIS ON  
ONE ENGINE

by JACQUES ELSNER, *engineering and procurement manager,  
North, Central American and Caribbean Division, Air France*

In September, 1956, Air France ordered 12 Sud Aviation Caravelle SE-210's, and acquired an option for 12 more.

By the end of next year, the French Airline will be flying three of these planes.

Air France has been closely associated with the manufacturer in the experimentation on the Caravelle.

The first prototype rolled out of the factory in May, 1955. By May of 1956, she had accumulated more than 400 hr in tests carried out by the manufacturer and by the French civil aviation authorities. A restricted airworthiness certificate was then delivered and Air France was assigned the task of service-testing the airplane for about 500 hr. To this end, actual cargo operations were performed between France and North Africa during the summer, 1956. On November 10, the prototype was returned to Sud Aviation, having logged 1055 flying hr.

The second prototype made her first flight in May, 1956. Fully equipped, she was used for various tests (such as air conditioning, sound proofing, and radio) and readied for the extensive tour of South and North America made in May and June of this year.

Two other prototype airframes, numbers 03 and 04, have been built for static tests and under-water fatigue tests, which are scheduled to be completed in the summer of 1958.

The endurance tests conducted by Air France had several purposes: First to assess the commercial performances in actual operations; second, to develop the best operating procedures in all phases of flight and in marginal and emergency conditions; and third, to evaluate the equipment, the systems, and their maintenance characteristics.

Many flights were devoted to the investigation of marginal conditions. The plane was often flown on one

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C. G. A. Rosen, chairman

## SAE LOOKS OVERSEAS

"BUGS" ARE  
FEW AND  
EASY TO  
CORRECT

engine, including three whole trips from Algiers to Paris. On several occasions one engine was stopped at the minimum take-off safety speed to watch the behavior of the plane under such conditions. The influence of icing was examined. Ground handling characteristics, exhaust blasts, heat, and noise were also investigated with the cooperation of the French Civil Aviation authorities.

To assess the long-range capabilities of the equipment, the aircraft was flown nonstop from Paris to Casablanca and back (2100 nautical miles).

Air France service test has confirmed our hopes for the Caravelle and the inherent advantages of her design.

Performances were found very close to those originally indicated by Sud Aviation. As they stand, they are, in our opinion, superior to those of existing airplanes and comparable commercial equipments due to fly in the near future. Of course, if compared to the long-range quadrijets under construction, they appear at a disadvantage. However, in such comparison, one should keep in mind that the aerodynamic qualities of the Caravelle airframe will allow it to take full advantage of future increase in the powerplant ratings. When this happens, the performances of the Caravelle will give, on short and medium route segments, block-to-block times close to those attainable with contemplated short-range quadrijets. The manufacturer asserts that increasing the  $V_{NO}$  (maximum speed in normal operation) will not be a difficult problem.

The handling qualities were excellent. No snag was found in the piloting in near-the-ground phases. This is important for an aircraft due to make many landings and will help keep operational weather minima low.

The general behavior of the equipment was good. Certain areas, however, warrant corrective actions on the part of the manufacturer. The windshield panels de-fogging and the cockpit lighting should be improved; in case of system failure, the manual control of the cabin air pressure and temperature is difficult. The electrical system functioned well but a larger power supply might be necessary to provide for the accessories likely to be incorporated. Hydraulic system reliability was

# SAE LOOKS OVERSEAS

good. Brakes were effective; yet we contemplate installing thrust reversers.

The above points can be corrected without too much difficulty. In this action, we will endeavor to preserve the basic simplicity of the systems, which, in our opinion, is a major asset.

COST OF  
MAINTENANCE  
SHOULD BE  
LOW

The maintenance of the plane during the endurance tests was Air France's responsibility, and we also tried to evaluate the characteristics in this respect. No particular difficulty was encountered and, except for several isolated areas, we found the Caravelle comparable to equipment now in use. When some improvements are incorporated, the cost of maintenance should be very low. In this regard, the superiority of the turbine engine was again stressed: maintenance was in actual practice limited to several resettings of the fuel controls.

NO EXTRA  
FUEL TANKS  
INSTALLED  
FOR  
ATLANTIC  
CROSSING

As far as the noise is concerned, our service testing emphatically showed the advantages of the twin-jet configuration of the Caravelle. The cabin is very quiet. Outside noise, even without silencers, will not give rise to the airport problems anticipated with the quadrijets and will stand comparison with the present piston-engine and turboprop airplanes.

The recent tour of South and North America made by the second prototype in May and June of this year was organized by Sud Aviation. Air France supplied the crew.

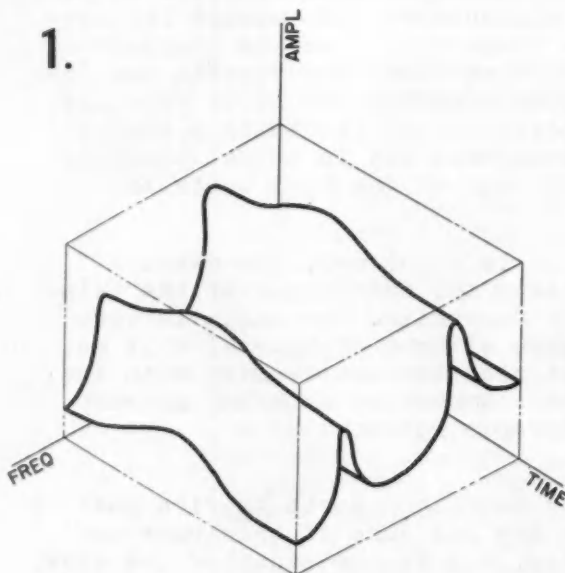
The plane had no special equipment. The two crossings of the Atlantic, the first one between Dakar and Recife (1700 nautical miles in 5 hr, 28 min), and the second from Gander to Paris (2200 nautical miles in 6 hr, 20 min), were made with no extra fuel tanks. In fact, at the end of both flights, about three metric tons (1000 U. S. gal) of fuel were still available representing a holding reserve of 2 hr. The electronic equipment included two high-frequency transmitter-receivers (Collins 618S), two vhf transmitter-receivers (STR 12), two ADF Marconi receivers, and one Lear automatic pilot. Besides, a periscope sextant was provided.

The whole trip went on schedule and the equipment gave rise to no particular trouble.

This feature is an activity of the SAE OVERSEAS INFORMATION COMMITTEE, C. G. A. Rosen, chairman

# Vibration Damage Evaluation

A complete analysis technique forms a standard for evaluating vibration damage. Shortcut methods can be judged by comparison with this method.



**Actual environmental** conditions form a surface with time, frequency, and amplitude coordinates. The amplitude is plotted in random or periodic units depending on the conditions found. These data are obtained from the flight test and ground handling vibration record.

**T**O pinpoint vibration damage, ten fundamental steps have been outlined by the Receivers Subcommittee. They provide a standard against which less exhaustive methods can be evaluated and point to future investigations needed.

"Vibration environment" is the actual or laboratory vibration applied to the base or mount of the part under inspection. It is assumed to be relatively steady-state, of the random or periodic variety.

"Fragility" is the transmitted vibration level at which malfunction (temporary unsatisfactory operation) or failure just occurs. The transmitted vibration is identical to the environment vibration if there is no mount between the part and its supporting chassis. If this is not so the modification of the environment vibration by the mount must be calculated.

In all the illustrated steps the mass of the chassis is assumed great and the steps must be repeated for each of the three directions of motion.

Based on a report of the Receivers Subcommittee of the SAE Shock and Vibration Committee (S-12). Members of the Subcommittee are:

F. B. Safford, chairman, Northrop Aircraft

H. Himmelblau, North American Aviation

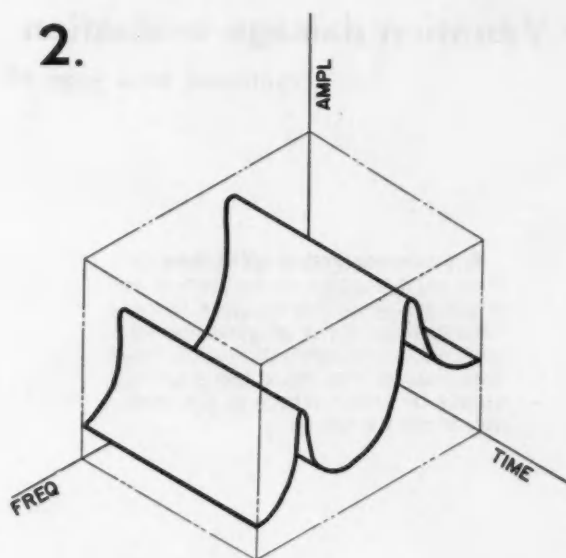
W. S. Inouye, Northrop Aircraft

K. Kuoppamaki, Naval Ordnance Laboratory

E. H. Lahnala, Collins Radio

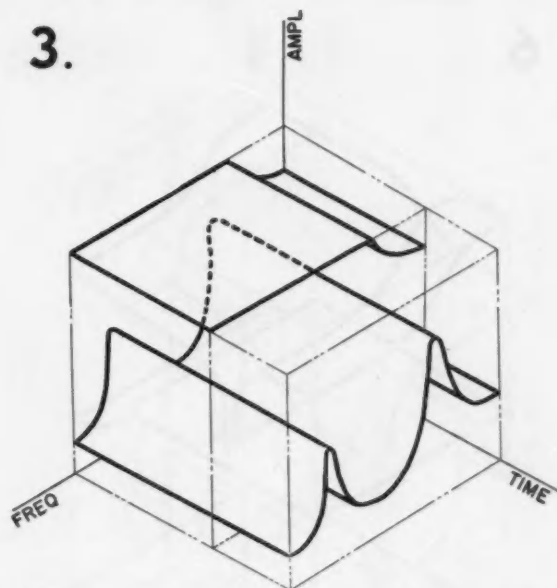
Dr. S. Rubin, Lockheed Aircraft

2.



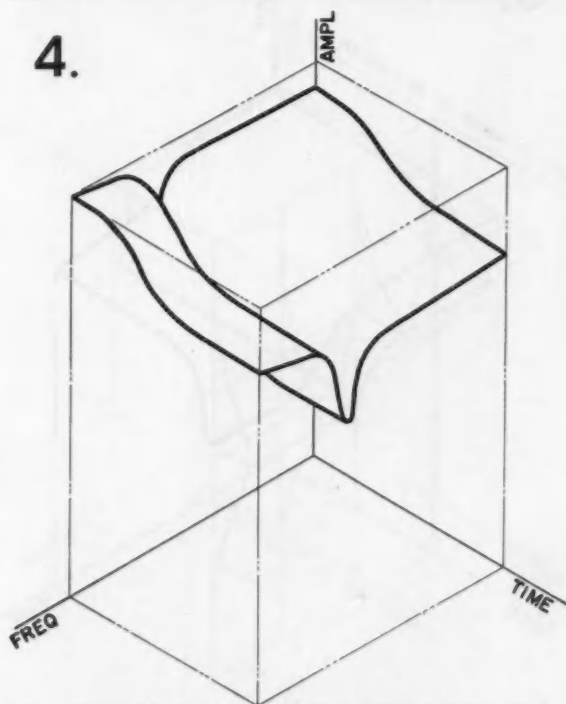
A steady-state simplification of actual environment produces a surface that is constant with time. This assumption is used through the analysis.

3.



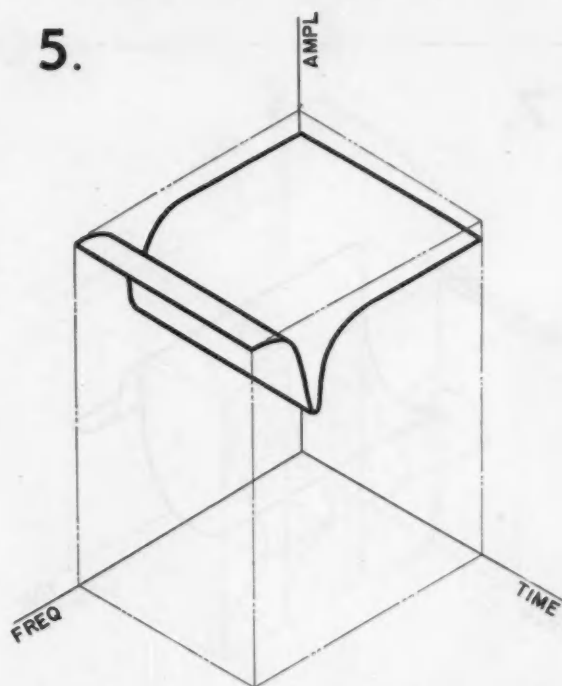
Laboratory simulation of environment usually takes the form of a simple surface that includes the actual values. This assumption usually has a greater amplitude for a shorter period of time.

4.



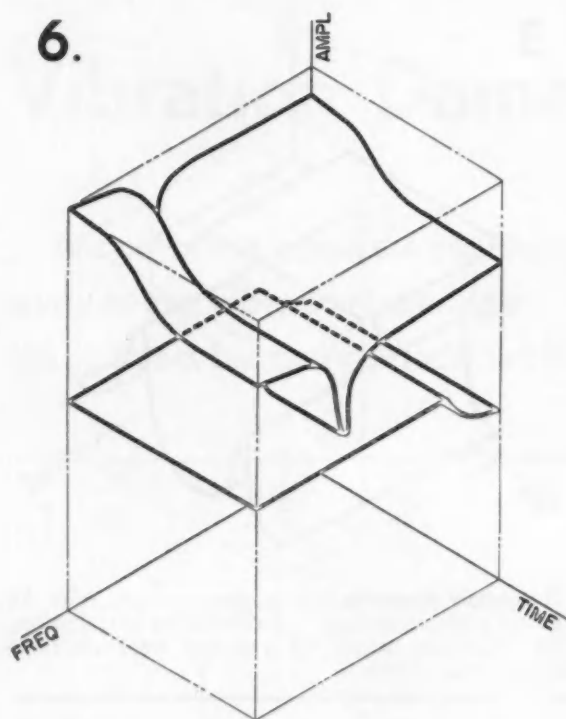
**Fragility** of a part also varies with time, frequency, and amplitude of vibration. It is the point at which malfunction or failure **just** occurs. These data may be obtained by vibrating the part at constant frequency and amplitude until failure occurs. Curves of this type are typical of metal fatigue failures. Solution of the overall probability of failure with this type of distribution is not readily solved.

5.



An example of part malfunction, such as relay chatter, will result in a simplified curve independent of time. In this case the data are obtained by increasing the amplitude of vibration until failure occurs at each test frequency. The reverse procedure can also be used but leads to some difficulty in comparison with environmental data when statistical distributions are examined. (Con't on p. 50)

6.

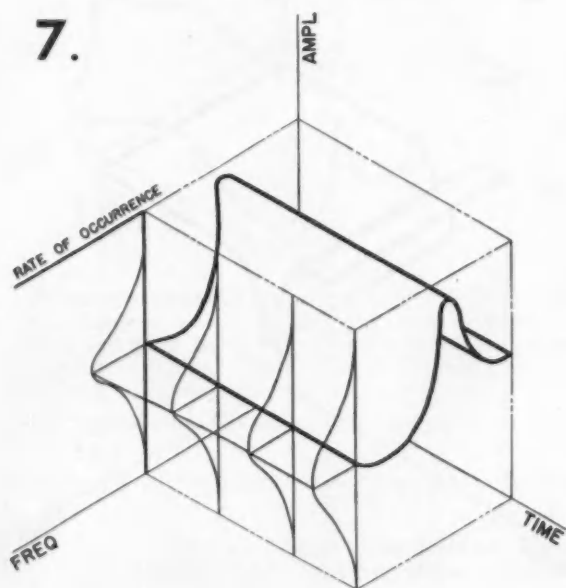


## • Vibration damage evaluation

continued from page 49

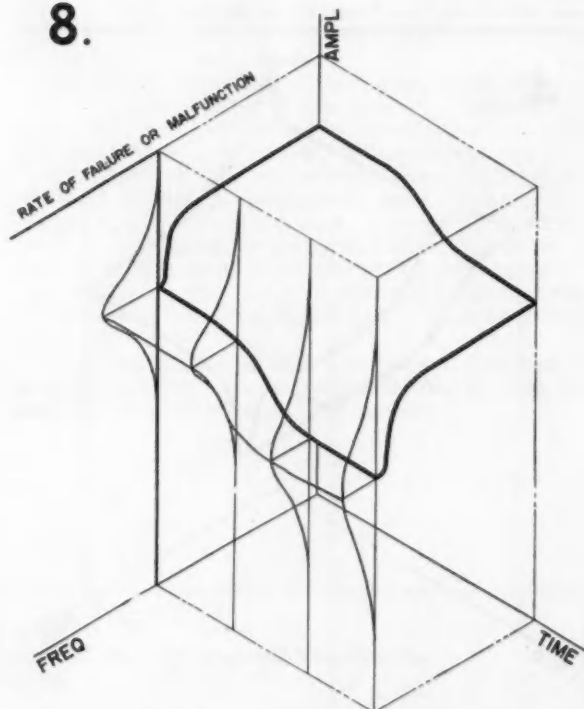
A production test fragility level is often set for a part in the form of a simple surface. This must be below the actual surface or all parts may be scrapped. Intelligent setting of this level requires that the actual fragility surface be known otherwise the level may be set too low.

7.



Since a fixed amplitude at a given frequency is not experienced in actual conditions, a distribution curve must be added to the environmental conditions. A Gaussian distribution is assumed. This forms an environmental "blanket" which can be described in terms of its mean amplitude and standard deviation.

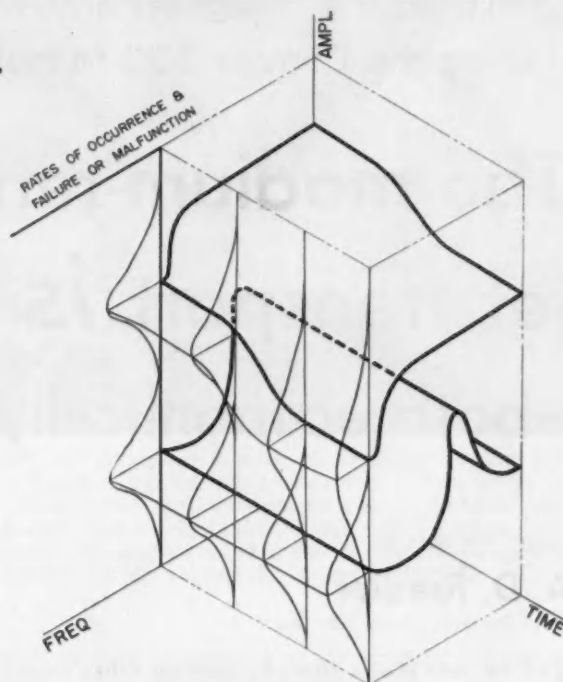
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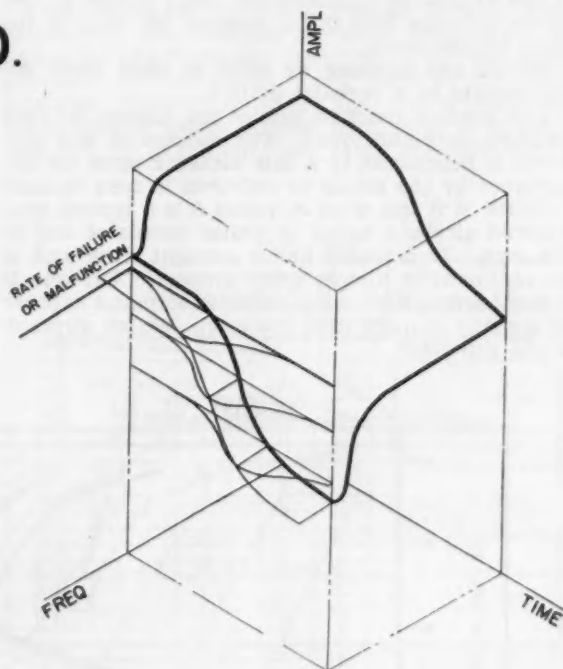
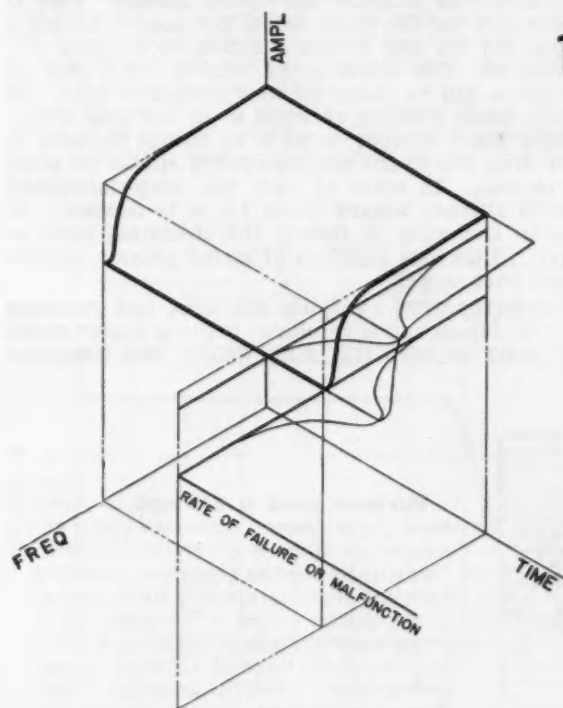
Applying the distribution blanket to the fragility surface accounts for the variations in production of delicate parts. Actually this blanket cannot be calculated directly since this surface was found by holding amplitude and frequency constant until failure occurs. However, the technique is directly applicable to parts that fail independent of time.

9.

Combining the blankets of the fragility and environmental surfaces gives an overlapping of distribution curves. The probability of failure at a given time and frequency can be found from the respective mean amplitudes and standard deviations.



10.



In general, the distribution blankets with respect to frequency and time should also be calculated. Shown are such possible fragility blankets (illustrated with and without time variations). The effect of all three types of blanket should then be combined to give the TOTAL probability of failure. At the present time the exact relationship between these blankets is not known. Also techniques for obtaining all environmental and fragility data may prove difficult.

Practically, various methods of predicting failures may be compared to this standard to evaluate their relative merits.

Questions the designers answered before starting the Convair 880 to make sure that

Abridged from an

SAE Met. Section Paper

# The medium-range jet transport *is* feasible —both economically and technically

Excerpts from paper by

**A. D. Riedler**

Design Specialist, Convair (San Diego)

**ARE we sure that a short-to-medium range transport airplane is desirable?**

The answer is emphatically "yes." Trips of between 200 and 2000 miles account for 90% of today's airline travel.

**Should the airplane we build to meet these requirements be a turbojet plane?**

The public's reaction makes the answer to that another emphatic "yes." The success of any airplane is dependent to a fair measure upon its acceptance by the public as reflected in load factors.

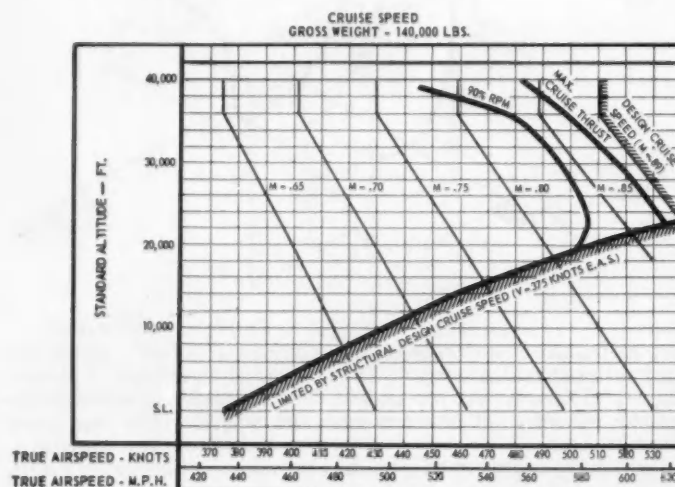
Think of it this way: Airplane A is a typical propellered airplane flying at cruise speeds of 300 to 350 mph. It probably has a straight wing and is conventional in almost every respect. Airplane B is a modern, swept-wing turbojet airplane capable of cruising at more than 600 mph. Which airplane would you ride?

The lower operating cost of airplane A may be of little consequence if nobody cares to ride it. Besides, it may not even have lower operating costs.

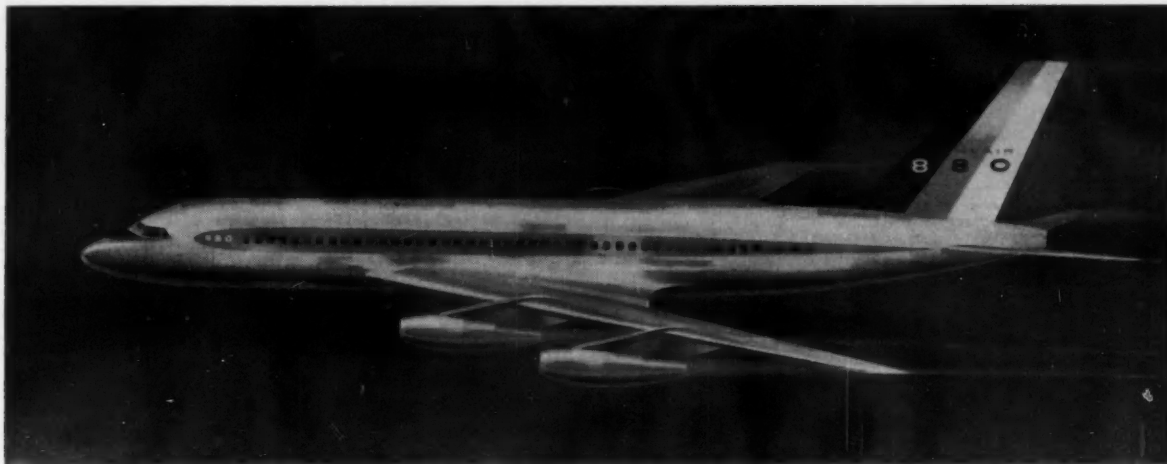
**Can we get high block speeds at the shorter ranges?** Or will climb and descent on short hops bring average speed way down below cruise speed?

High block speeds are possible. First of all, it is necessary to increase the cruise speeds. This is necessary for the block speed, but also to assure a long life for the airplane before it becomes obsolescent. The cruise speed must be such that no airplane will fly faster for long periods of time. At some Mach number, referred to as the drag-divergence Mach number, there is an abrupt increase in the drag due to the compressibility effects on pressure drag. In order to push this drag-divergence Mach number toward Mach 1.0, it is necessary to sweep the wing or reduce the thickness ratio or both. Judicious selection of airfoil plays a significant part as well.

Unfortunately, sweeping the wing and reducing the thickness ratios results in reduced aspect ratios in order to keep the wing weight and flexibility



**Maximum speed is 615 mph** at maximum cruise power. Maximum speed occurs at an altitude of about 22,000 ft. This altitude provides good direct operating costs and allows satisfactory traffic control at the shorter ranges. The speed cutoff at the lower altitudes is caused by a structural design limitation of 375 knots equivalent airspeed. This is somewhat higher than other transport airplanes, thereby providing speed advantages at even the shortest ranges.



The Convair 880 has a wing span of 120 ft, an overall length of 129 ft 4 in., and a height of 36 ft 0.3 in. The wing area is 2000 sq ft, with a sweep of 35 deg. The fuselage has accommodations for 84 passengers in true first-class style, with four abreast seating and an additional four seats available in the lounge. There also are provisions

for rapid conversion to a five-abreast coach airplane with 109 seats. The fuselage cross-section, with a 128-in. inside diameter, provides room for five comfortable coach seats or four luxurious standard seats with a spacious 28-in. aisle. The engines selected for the 880 are the General Electric CJ-805, commercial version of the J-79.

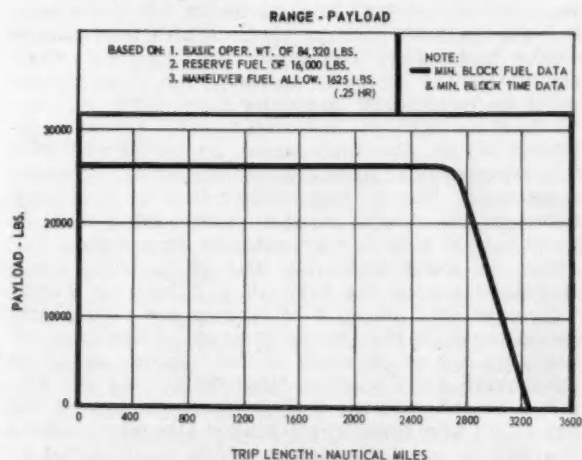
within tolerable limits. The increase in sweep and reduced thickness ratio also tend to compromise the low-speed characteristics such as maximum lift and stability. The reduced aspect ratio also reduces the range and climb characteristics. Consequently, it is necessary to compromise between the high- and low-speed characteristics.

Another method of increasing cruise speeds is to provide structures capable of handling relatively high maximum indicated airspeeds so that the full

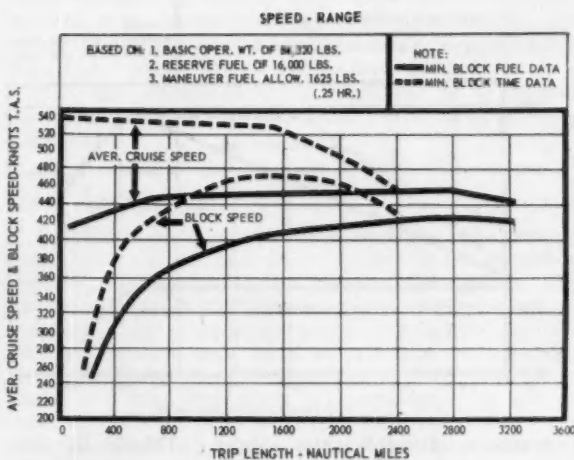
performance capabilities of the airplane will not be hindered by the structural design.

#### How can we reduce the climb and descent times?

Climb times are reduced by keeping thrust/weight ratios high and choosing the best compromise between the improved fuel consumption of the higher altitudes and the lower climb times of the lower altitudes. Descent times are kept low by providing speed brakes, which provide high rates of descent, and also by providing high cabin pressure differ-



Range actually goes to 2650 nautical miles with the full coach payload of 26,320 lb. This is the first important by-product of design for short-to-medium range. The wing area required for short landing distances provides large fuel volume while the high take-off thrust required for the high speed provides sufficiently high allowable gross weights to use the fuel volume.



Average cruise speed and accompanying block speed are also a function of range. An average cruise speed of more than 600 mph is available at the shorter ranges and provides block speeds of 400 mph at a range of 400 statute miles. Speed is lower at the longest ranges because of adjustments in thrust and altitude. Dashed line refers to time data; solid line to fuel consumption data.

entials, which prevent the high descent rates from causing passenger discomfort.

High thrust/weight ratios are required for the high speeds as well as the high rates of climb. The thrust/weight ratio can be increased obviously by

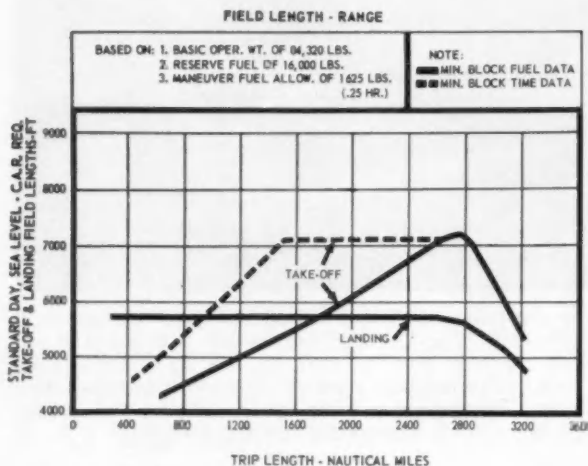
either increasing thrust or decreasing weight. The business of decreasing weight is important on every airplane and doubly so on this type of airplane. The weight is reflected in the airframe cost as well as the performance, and it is this cost which determines the airframe depreciation, maintenance, and insurance—accounting for 30 to 40% of the hourly costs.

Increasing the thrust is the other alternative, but because of the importance of weight the engine's specific thrust deserves careful scrutiny. Consider the engines available for a short-to-medium range transport. One can array them with respect to availability and thrust class. The availability is of considerable interest because of airline requirements, production loads, and, of course, competition. It is also necessary to select an engine which is near the infield of the ball park in which you are interested. The engine should be a "dry" one, requiring neither water injection nor afterburning to obtain its performance. This is necessary to provide low maintenance, ease in ground servicing, and lower levels of noise near airports. It should also be an engine which has a lot of "back-up," that is, complete assurance of the success of the engine development program is required to secure the wedding of the correct engine with the correct airplane.

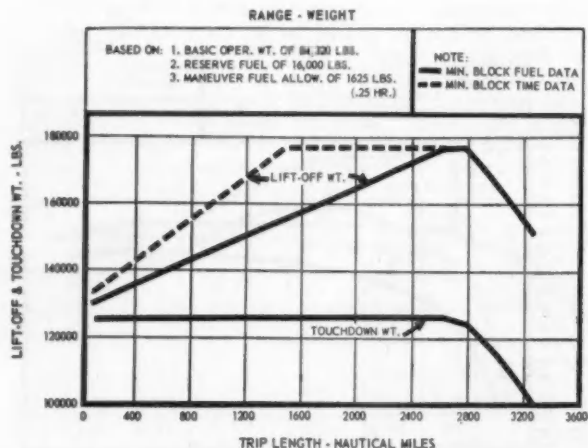
Another factor in the direct operating cost equation is the payload. Let it suffice to say that the payload is obtained after a consideration of the market for seat miles, the effect of fuselage size on airplane speed, and the other economic factors involved. Certainly it is also desirable to obtain a passenger capacity which can be adequately handled by our present short supply of ticket sellers and by loading facilities now in use.

Can the small-to-medium range jet transport get into the airports appropriate to its type of operation?

It is extremely desirable to keep the public's investment in concrete to a minimum. Airports serving the short-to-medium range routes characteristically have short-to-medium field lengths. Consequently, any airplane designed for those ranges must be capable of operating from fields at least as short as those in operation today. As was mentioned before, the high speed design of the wing will necessarily compromise the maximum lift characteristics. These compromises can be overcome, however, by several means. Large wing area in conjunction with a very efficient flap design can offset the lower maximum lifts of the wing itself, thereby reducing the take-off and landing speeds. This pays off because field lengths are very nearly proportional to the speeds squared. Additional advantages can be obtained in the stopping distances by providing lift spoilers (thereby getting the airplane weight onto the wheels where the brakes can get at it) and nose-wheel brakes (thereby braking the 20% or so of the weight which is supported by them). The take-off distances also are improved by providing high thrust/weight ratios. Fortunately, these come about quite naturally when a medium-range airplane is designed to cruise at very high speeds.



Landing distance is constant at 5800 ft with range since it is dependent only on the payload carried. It is also the governing distance at ranges up to 900 to 1750 miles, at which range the take-off distance takes over. At the short ranges the field lengths are short, generally 6000 to 6500 ft. At the longer ranges the airplane will be going between larger cities where longer fields are available. For instance, a trip from Los Angeles to New York will require approximately 7200 ft of field, which is considerably less than that available at either point.



Maximum allowable gross weight is 178,500 lb. The variation of ramp weight (lift-off gross weight plus taxi and take-off fuel) with range is shown here. When the maximum allowable gross weight is reached further gains in range can be obtained by adjusting thrust and altitude. The high cabin pressure differential of 8.2 psi desirable for passenger comfort during climb and descent allows the airplane to cruise at altitudes of 40,000 ft while maintaining a cabin altitude of only 8000 ft.

To Order Paper No. S3 . . .  
... on which this article is based, turn to page 5.

# Automobile Body Manufacturing Organizes for Controlling Costs

Based on paper by

**F. S. Altman,**

Fisher Body Division, General Motors Corp.

**M**ANY groups make up the task force which is used to attack the problems of automobile body manufacturing. Their main objectives are to improve the product and reduce its cost. Various techniques are used by management, production engineering, tool engineering, and other production groups to carry out these objectives. Indirect savings resulting from their efforts are just as important as direct savings derived through the use of tooling techniques and materials.

## **Management**

Management has many activities and functions to perform in the operation of the organization which eventually will have an effect upon the cost of production tooling. Among other things, it directs the movement of men, monies, and materials. It selects the product and sets a competitive market price. It assumes the responsibility for determining the overall cost that can be applied to the tool-up program, the quantity of new capital equipment to be purchased, the burden and amortization of all tools and equipment.

To accomplish this, management holds meetings with product, die, and tool engineering, construction and production to discuss overall planning, tooling, and production problems.

## **Product Engineering**

In the automobile body business, product engineering's chief responsibility is to take the styling

lines which are received from the body stylist and develop the working drawings of bodies which will be of competitive quality, capable of being manufactured at a profit, at the rates of production, and in the quantities scheduled by management. This responsibility is far more than just the solution of a technical design problem. It means that manufacturing methods, processes, assembly techniques, and related operations must have their effect on the configuration of the body assembly.

To achieve this goal, body engineering meets with tool and die engineering to determine the general plan for assembling the body, the location and types of joints between panels and sub-assemblies, and the finishes required in those areas.

The end result of these meetings is a product which can be tooled and manufactured more economically.

## **Tool Engineering**

The rapid expansion of industry created the need for a specialized and more concentrated study of each phase of product and tool manufacturing. The tool engineer is the result of this more analytical approach for attacking production problems. In many organizations, he is responsible for planning and providing all of the tools, machines, and processes for manufacturing the product. In others, this responsibility is divided. Let us consider the tool engineer as having all of the forementioned duties and responsibilities. In carrying out these responsibilities, it is necessary for him to coordinate his efforts with all other groups in the manufacturing organization.

The tool engineer must have an active, inquisitive mind and a broad knowledge of manufacturing processes, tools, and equipment. He must have an inner drive that keeps him in a state of construc-

tive discontent which in turn stimulates new methods, new materials, and new tools.

In every sense of the word, tool engineers working for different manufacturers feel that they are just as much in competition with one another as the dealers who sell the finished product. This competition has been responsible for the development of many of our present day tooling techniques and materials.

### **Construction and Production**

It goes without saying that the tool construction and production groups are also active in tool cost reduction. Working with other member groups, they contribute information and data which is needed in engineering and management activities.

The construction group works directly with the tool engineer in the development of new lower cost tooling techniques and materials.

Production groups work with both product and tool engineering, not only in the improvement of current tooling and production techniques, but also in testing and evaluating new processes for possible future use in the shop. Cost savings are realized when recommendations from construction and production are considered in the early stages of product and tooling engineering.

### **Forward Planning**

There was a time when industrial organizations didn't plan their tooling requirements too far in advance of actual need. The demands of faster rates of production and increased competition have changed this. Today, advance or forward planning plays an important part in tool cost reduction.

Forward planning is a systematic procedure of forecasting future tooling needs based on analyses of past tooling programs and projected plans for the new model.

Savings are realized because forward planning permits advance ordering of raw materials, tooling standards, and commercial items so that they can be delivered as required for the tool building program.

### **Communications**

The control of communications is sometimes overlooked as a phase of manufacturing where worthwhile savings can be realized.

In a large corporation, the flow of information, data, and directives takes on huge proportions. Each division, plant, activity, or department must get its signals straight so it can help to carry the ball in the same direction. Communications within a corporation must be organized to feed forward and feed back, to provide full information needed for decisions, as well as to transmit those decisions rapidly and clearly.

Misunderstanding regarding production schedules, the incorporation of engineering changes, cancellations, and the quantities of tools required can be costly.

**To Order Paper No. S15...**

... on which this article is based, turn to page 5.

# **STOL Coming**

Based on paper by

**R. Bannack,**

DeHavilland Aircraft of Canada, Ltd.

**W**HILE high-speed, high-flying aircraft have been grabbing the headlines, quiet but substantial progress has been made in the development of aircraft to "go lower and slower."

This development is being made in response to military and civil demand for airplanes which will carry greater payloads at less cost. These users frown on high speed because to obtain it means high wing loadings, which in turn means high stalling speeds with resultant long take-off and landing runs.

Not many countries outside the North American continent can afford more than one or two costly terminals, yet air travel is everywhere desired. Speed is relatively unimportant in eastern Asia, for example, because even at 150 mph the savings in travel time are enormous. The airline operator in Indonesia or the Philippines hasn't 5000-ft runways scattered around outside the capital cities. The best those countries can afford are 1000-ft runways made by leveling off or filling in a rice paddy, or hacking a strip out of a jungle. What the operator needs here is a transport capable of short take-off or landing, simple and rugged in construction, and able to withstand extremes of climate—in short, the STOL airplane.

The military likewise wants the STOL airplane. It wants to put wings on jeeps and trucks to move troops and their equipment "as a crow flies," rather than stick to vulnerable surface routes which may be virtually nonexistent as in Korea. During the past seven years, the U. S. Army has integrated approximately 2400 STOL types into its field units. And the Research and Development Division of the Army is currently pressing basic research by devel-

# Aircraft

## to the Fore in Many Countries

oping flying test beds to investigate various new systems of short or vertical take-off and landing. Among these are:

- Boundary layer control.
- Deflected slipstream.
- Rotatable ducted fan (Hiller Flying Platform).
- Tilt-wing principle.
- Deflected jet.

Note that the development of the helicopter or purely vertical take-off and landing type is ignored here. The helicopter has shown that it plays a very important role, but it is costly to operate on a commercial basis. Actually, it is perhaps five times as costly per hour, on a ton-mile per hr basis, as a comparable fixed-wing transport. It is doubtful if the helicopter can ever become an economical commercial transport, at least not before the STOL type is sufficiently advanced to fill the "flying truck" and "flying bus" needs of the air transport industry.

### DeHavilland's STOL Developments

The Beaver, the first STOL design venture of DH Canada, was started 10 years ago. The company was seeking primarily a good seaplane for the Canadian bush operator. The incorporation of large slotted flaps, together with drooping ailerons, was a novelty and produced outstanding take-off performance in a seaplane. The land plane take-off was even better. With a payload of 1000 lb, the Beaver can take-off and land with a ground run of approximately 600 ft (no wind condition) which means a safe operation out of a landing strip no more than 1000 ft in length.

Success with the Beaver spurred development of the Otter, which carries double the payload. The Otter has full span double-slotted flaps, and although not high powered by modern standards, the combination of thrust and lift makes possible carrying a 1-ton payload out of a 1000-ft strip.

Over 1000 Beavers have been built and they are being operated in 55 different countries. Among export customers the Aero Taxi Avianca in Colombia is typical. It uses 15 Beavers on a bus service between Bogota and Barranquilla along the Magdalena

River, landing on short, rough strips in villages along the river. Fares are comparable with boat transportation, with the Beaver running at 130 mph as compared with the boat's 5 mph. Biggest customer is the U. S. Army, which uses 600 Beavers (termed L-20), using them literally as ½-ton airborne trucks, generals' staff cars, flying jeeps, and ambulance aircraft. During the Korean War, 50-odd Beavers airlifted an entire regiment in a half day, a distance of 50 miles over a mountain range from one valley to another, using blocked off sections of gravel road for landing strips.

Almost 200 Otters have been built and supplied to Canadian bush operators, the RCAF, USN, USA, and a few overseas operators. Because the Otter is capable of operating off glaciers and confined spaces, 10 are being used by the U. S. Navy in Antarctica. Here it is being used to airlift the Geophysical parties of the International Geophysical Year.

Until two years ago, Philippine Airlines operated a fleet of DC-3's around the Island from half a dozen aerodromes. Now, with five Otters, over 30 short grass strips hacked out of the jungle bring transportation to scattered villages.

### Latest Development—the DHC-4 Caribou

Profiting from experience with the Beaver and Otter, a still larger STOL transport, the DHC-4 Caribou, is under development. It will be designed to carry a 2.5-ton payload and take-off and land in a run of approximately 500 ft, which means operating from a 1000-ft strip. Bearing in mind Army mobility requirements, it will have a tricycle undercarriage, rear-end loading to facilitate quick loading at truck-bed height and, most important, to provide quick exit for parachuting the entire cargo.

Among prediction of things to come, one should include, within the next 10 years, STOL transports with high lift and load speeds, carrying 30-40 passengers in the form of "flying buses," operating out of short strips to provide fast transportation between the smaller cities and towns.

▲ To Order Paper No. S25 . . .

. . . on which this article is based, turn to page 5.

# Instruments Measure Unburned Hydrocarbons

Based on paper by

**J. C. Neerman and G. H. Millar**

Ford Motor Co.

**T**WO instruments, an infrared interference photometer and a viscous matrix airflow meter, permit measurement of incompletely burned hydrocarbons in automotive exhaust gas.

The photometer (Fig. 1) consists of a heated Chromel A ribbon infrared source, an electrically-operated shutter, a 20-in. sample cell, the interference filter, and a compensated thermopile detector. A pump provides continuous flow through the cell, and an electrically-operated 3-way valve selects either exhaust sample or reference air for measurement.

The particulate filter is an 11.0 cm diameter glass

fiber filter paper supported between two 10-mesh nichrome screens.

The measuring circuit is of the null indicating type, with potentiometer dial calibrated to read directly in percent transmittance for manual null balancing. Provision is also made for attaching a self-balancing recorder for measurement of transient conditions such as deceleration. A 4-position ganged selector switch provides proper photometer shutter and valve positions for zero adjustment, 100% adjustment, or percent transmittance measurement.

Control circuits are housed separately from the photometer to allow remote operation. The control box contains the measuring circuits together with the photometer shutter and valve controls. An interconnecting electrical cable allows complete operation of the photometer from the control box location, which may be several feet from the photometer in certain mobile installations. For mobile op-

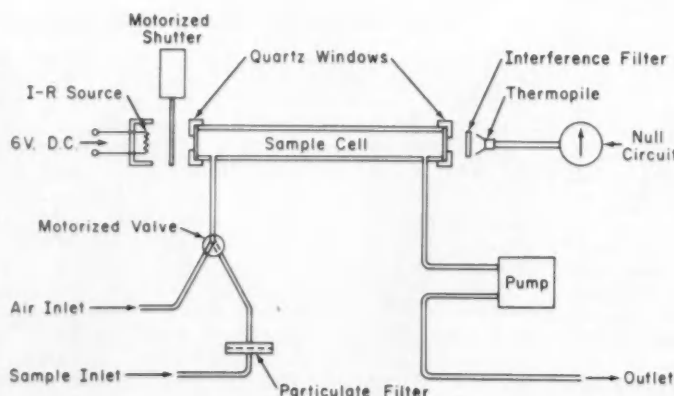


Fig. 1—The photometer consists of a heated Chromel A ribbon infrared source, an electrically-operated shutter, a 20-in. sample cell, the interference filter, and a compensated thermopile detector. A pump provides continuous flow through the cell, and an electrically-operated 3-way valve selects either exhaust sample or reference air for measurement.

# in Auto Exhaust

eration, power for the equipment is supplied from a storage battery and converter.

## Calibration

The analyzer is initially calibrated by introducing measured hydrocarbon-air blends into the sample cell on a continuous flow basis. A diagram of the calibration equipment is shown in Fig. 2. Since a pure hydrocarbon is easier to handle than a mixture such as gasoline, a representative pure paraffinic hydrocarbon was selected for the calibration. Normal hexane was felt ideal since its absorptivity closely approximates that of a typical gasoline.

A range of hydrocarbon concentrations in air is provided by adjusting the needle valves to divert various fractions of the total airflow into the flask containing the n-hexane. The hydrocarbon concentration is determined by measuring the total airflow with a gas meter and the weight of n-hexane

evaporated during the same period of continuous operation. The mole percent n-hexane can then be plotted directly versus percent optical transmittance.

## Operating Procedure

The analyzer can be mounted on a cart adjacent to the engine or vehicle for stationary tests. For road operation the photometer is placed in the trunk permitting a short sampling line from the tailpipe. The control unit and recorder are then located inside the car for convenience.

On dynamometer-mounted engines, samples are obtained at a point a few inches upstream from the muffler. For vehicle tests a sampling probe reaches about 3 ft upstream from the end of the tailpipe. This is essential because of the possibility of air dilution near the end of the tailpipe.

Since the high percentage of water vapor in engine exhaust might condense in the system, the bulk

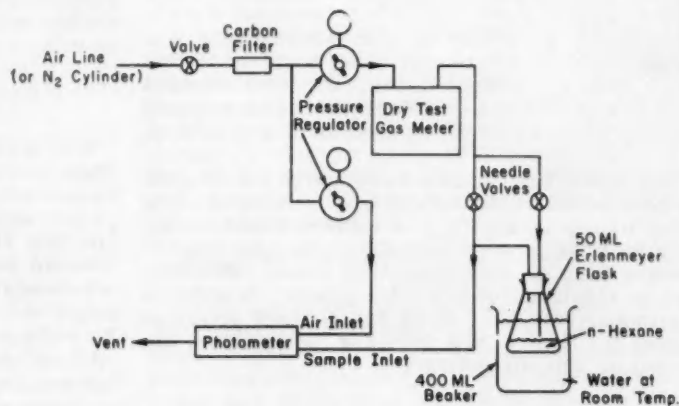


Fig. 2—Equipment for dynamic calibration of photometer. A range of hydrocarbon concentrations in air is provided by adjusting the needle valves to divert various fractions of the total airflow into the flask containing the n-hexane. The hydrocarbon concentration is determined by measuring the total airflow with a gas meter and the weight of n-hexane evaporated during the same period of continuous operation.

of the water is removed from the sample prior to analysis. Either Drierite or a simple air-cooled condenser serves to remove water sufficiently to prevent serious interference with the hydrocarbon measurement.

Before making determinations the analyzer source is turned on for several minutes to allow the instrument to reach a stable operating temperature. Subsequently, the steps in operating the analyzer correspond to the typical procedure for photometry. Zero and 100% transmittance adjustments are made, the sample is introduced, and sample transmittance is read from either the potentiometer dial or recorder. A calibration curve provides the corresponding concentration of unburned fuel.

#### Airflow Meter

A viscous matrix flowmeter was developed to measure and record carburetor intake airflow on a moving car. This instrument fulfills the need for an airflow meter to be used in conjunction with a portable infrared exhaust-gas analyzer to determine the rate of emission of exhaust components from vehicles on normal road operation.

The instrument was required to impose no modifications or abnormal operating conditions on the vehicle. In addition, it had to be rugged, portable, compact, simple to use, and readily adaptable to a variety of automobiles.

The usual method of measuring carburetor air flow in the laboratory is by means of calibrated orifices, in which the flow is proportional to the square root of the pressure difference. If the flow is pulsating, a large surge drum is required to smooth out the flow through the orifice. Damping the differential pressure measuring device gives the arithmetic average pressure drop, which does not indicate the proper average of a pulsating flow (because of the square root relationship). With a viscous flowmeter, however, in which laminar flow is maintained, pressure drop is directly proportional to flow. Hence, a damped differential pressure measuring device indicates the correct average of a pulsating flow, and no surge drum is required.

Previous experience with airflow measurement suggested the possibility of developing a viscous type element to replace the standard automotive air cleaner.

One major advantage of this type element was compactness, since no surge tank would be necessary. Evidence indicated that the flow element could be installed in a standard air cleaner housing and that adapters might be used to fit a variety of cars.

Care would be required, however, to insure that the carburetion of the vehicle was not altered. The pressure drop across the flow element would necessarily be small to be within the normal air cleaner pressure drop at equivalent flow rates. Measurement of this small differential pressure is difficult in a moving vehicle. Since the concept appeared feasible for the purpose intended, however, an investigation was undertaken.

#### Flow Element Geometry

Laminar flow may be created by reducing velocity, or reducing hydraulic diameter. In designing a flow

element for vehicle use, two additional factors must be considered—pressure drop limitations and flow element size.

To minimize the effect of the flowmeter on carburetion, an attempt was made to have the flowmeter operate within the same pressure drop range as the standard air cleaner. In addition, the flowmeter was designed so that air entered the carburetor in essentially the same path as that provided by the standard oil bath air cleaner. Investigation of air cleaner performance indicated that 1 in. of water pressure drop for 100 cfm of engine airflow was typical.

#### Triangular Section Matrix

The triangular section matrix appears desirable for the flow element. The triangular section is formed by winding a crimped aluminum or stainless steel strip and a flat strip together in a spiral. Thus a matrix element is formed in which all of the passages have the same geometry. The passages are equilateral triangles 0.038 in. in height. Aluminum 0.004 in. thick was used on the first prototype units; however, stainless steel 0.002 in. thick has been used on all recent meters.

The length of a tubular passage determines the pressure drop for a given quantity of flowing fluid. Engine compartment dimensions limited the practical length to about 3 in. With an experimental matrix of 3 in. path length, it was determined that about 27 sq. in. of matrix would produce 1 in. of water pressure drop at 100 cfm of airflow. On this basis a series of flow elements were fabricated in both 2-barrel and 4-barrel carburetor air cleaner housings. Separate flow element designs for 1- or 2-barrel and 4-barrel carburetors were used because of the large difference in typical dimensions and maximum airflow.

#### Accuracy of the Flow Measurements

Although the initial intent was to produce an instrument of 10% accuracy, the present instrument appears to be considerably better, perhaps near 4 or 5%, based on operation in series with standard dynamometer airflow measuring equipment. If an instrument of 1 or 2% accuracy were desired, a more critical examination should be made of the effects of pulsations, dirt accumulations, and water.

#### Dirt Causes Errors

Due to the size of the passages in the flow element, these instruments are subject to errors due to an accumulation of dirt in the flow element. The only apparent solution to this problem is a filter ahead of the flow element and periodic cleaning. The flow element must be kept free of oil or other substances which might act as a collector for dust or dirt. With reasonable care, dirt accumulation does not seem to be serious. Some of the meters were field tested, without cleaning, for 4 weeks. Upon return to the laboratory, recalibration of these meters showed no significant change from the original calibration.

To Order Paper No. 168 . . .

. . . on which this article is based, turn to page 5.

# Integrator Determines Total Emission of Automotive Exhaust Gas Components

Based on paper by

**R. T. VanDerveer, J. D. Jenks,  
and R. L. Dennis**

Ford Motor Co.

**A** SYSTEM of totalizing the hydrocarbon emission from an automobile during operation has been developed and evaluated. The system involves the use of multiplying potentiometers to obtain the product of cfm of exhaust and exhaust hydrocarbon concentration. The product (cfm of hydrocarbon) is integrated electronically and totalized during vehicle operation as the accumulated weight of hydrocarbons emitted.

In constructing an instrument that would eliminate the need for graphical analysis and the type transient method of overall emission analysis, five primary problems had to be resolved:

1. The effect of an unavoidable hydrocarbon sampling delay.
2. Adaptation of the Model 15 Liston-Becker Hydrocarbon Analyzer to extended periods of operation.
3. Development of a means for electrically combining voltages representing airflow and hydrocarbon concentrations.
4. Adaptation of an existing quantizing voltage integrator.
5. Equating of airflow to exhaust flow.

## Sampling Delay

As the integrating system was envisioned, voltages representing airflow and hydrocarbon concentration would be instantaneously combined with the product representing exhaust hydrocarbon emission. However, the rate of change of hydrocarbon concentration lags the airflow rate changes at the point of signal combination. Considering any deceleration: at the moment of throttle closure the airflow drops immediately to the idle value due to the formation of a critical orifice. It is believed that a

corresponding instantaneous change occurs in the exhaust-gas hydrocarbon concentration due to the change in intake manifold pressure. However, this change is not immediately noticed at the hydrocarbon analyzer due to two factors:

1. The amount of time required for the concentration change to appear at the exhaust-gas sampling tap. This delay is a function of idle airflow and volume of the exhaust system to the sampling tap.

2. The time required to bring the sample from the exhaust system to the detection cell. This delay depends on the flow rate of the sampling pump and the pressure drop through the sampling lines.

This time difference in the response of the primary variables introduces an error proportional to the delay. The condition is at its worst during deceleration, when the magnitude of change of both variables is relatively great. Cruise and idle present no problem because both airflow and hydrocarbon concentrations are constant. Acceleration results in high airflows and low hydrocarbon concentrations. The gas sample flow rate is correspondingly high, and combined with the slow rate of change of hydrocarbon concentration introduces a negligible error.

Preliminary calculations indicated that an error of 10% on the low side would result if the delay time during deceleration could be held to 1 sec or less. This was felt to be acceptable inasmuch as traffic studies had indicated that the deceleration emission during the average traffic pattern amounted to 25-30% of the total, and an error during deceleration of 10% would introduce an over-all error on the low side of only 2.5-3.0%.

## Adaptation of Hydrocarbon Analyzer for Continuous Sampling

While the Model 15 Liston-Becker Analyzer had been used for continuous sampling in the broad sense of the term, it was actually continuous for periods of only 5 to 10 min. The chief problem was water and particulate matter in the gas sample which made frequent condenser and filter changes necessary.

The possibility of having the complete detection

unit operate at 200 to 250 F was explored but not pursued due to difficulties inherent in such a modification. Instead, heated sample lines, series condensers, and a particulate trap and filter were adopted. These modifications allow continuous running for periods exceeding 1 hr before condenser draining is necessary. Maximum zero shift for a 30 min period is only one meter division.

#### Electrical Multiplication of Airflow and Hydrocarbon Values

The equipment arrangement for the conventional determination of emission consists of two basic groupings:

1. The radioactive airflow meter with amplifier and Varian recorder.
2. The Model 15 Liston-Becker Hydrocarbon Analyzer consisting of the detection unit, amplifier, and Varian recorder.

To accomplish the desired multiplication of signals, the Varian recorders were modified to act as servomotors. This procedure allowed the use of existing equipment; and by utilizing the recorders as recorders as well as servomotors, the accuracy of the integrator could readily be determined under road conditions.

A potentiometer is coupled to the servo system of each amplifier. Therefore any voltage impressed upon the potentiometers varies in direct proportion to the deflection of the recorder. A 45-v battery is connected across one of the potentiometers with the output fed to the second potentiometer. This configuration produces an output voltage proportional to the instantaneous product of the two recorded variables. These instantaneous concentrations must then be integrated with respect to time to obtain total emission.

#### Voltage Integration

The integration is done electronically with an instrument which has an output pulse rate proportional to the output voltage from the multiplying potentiometers. The pulses from this integrator are then continually registered on a totalizing counter.

#### Equating of Carburetor Airflow to Exhaust Flow

While the radioactive airflow meter measures air mass directly, this figure cannot be strictly construed as exhaust flow. An exacting calculation for the conversion ratio requires the air-fuel ratio and the carbon-hydrogen ratio of the fuel used. For a fuel of  $\text{CH}_{1.86}$  the exhaust air molar ratio ranges from 1.062 at 10/1 air-fuel ratio, to 0.936 at 15/1 air-fuel ratio. No practical method could be found to correct for this effect, and therefore a 1/1 ratio on a dry basis was assumed. This corresponds to an average air-fuel ratio of 11.8/1. This discrepancy is of no importance in comparative evaluations using the same car, but for the absolute determination of emission it must be taken into account.

The complete paper on which this article is based also describes instrument evaluation and calibration procedures for the instrumentation mentioned in this article.

To Order Paper No. 169 . . .

. . . on which this article is based, turn to page 5.

## Fast burning, variable spark-timing, and Outboard

Based on paper by

**Hendrie Grant,**

Scott Atwater Mfg. Co., Inc.

IMPROVED fuel economy is a must for high horsepower, fuel-gulping, 2-stroke outboard engines, if they are to hold their edge on 4-stroke engine competition. Part-throttle economy is essential for "planning" motorboats which use less power once they are skimming over water.

To achieve good economy while developing a 40-hp engine, the Scott Atwater Co. beefed-up a 33-hp engine and added design features to maintain part-throttle economy. The first steps were to increase the horsepower and then to maintain full- and part-throttle economy.

#### Increasing the Horsepower

Engine breathing is deepened by improved reed valve design and elongating ports the equivalent of 5 deg of crank angle. The extra charge of air and fuel to the cylinder increases the horsepower just as opening the valve area of a 4-stroke engine increases its performance. To give more horsepower, the compression pressure is increased and cooling of the cylinder head stepped up.

Power loss by the reduced piston travel to the exhaust port is small. The increased volumetric efficiency gained by improved breathing far outstrips the power lost by the early "blowdown".

Changing the timing between exhaust and intake from 13 deg to 14 deg keeps the peak output at the 5000 rpm optimum speed for the 40-hp engine.

#### Improving Part-Throttle Economy

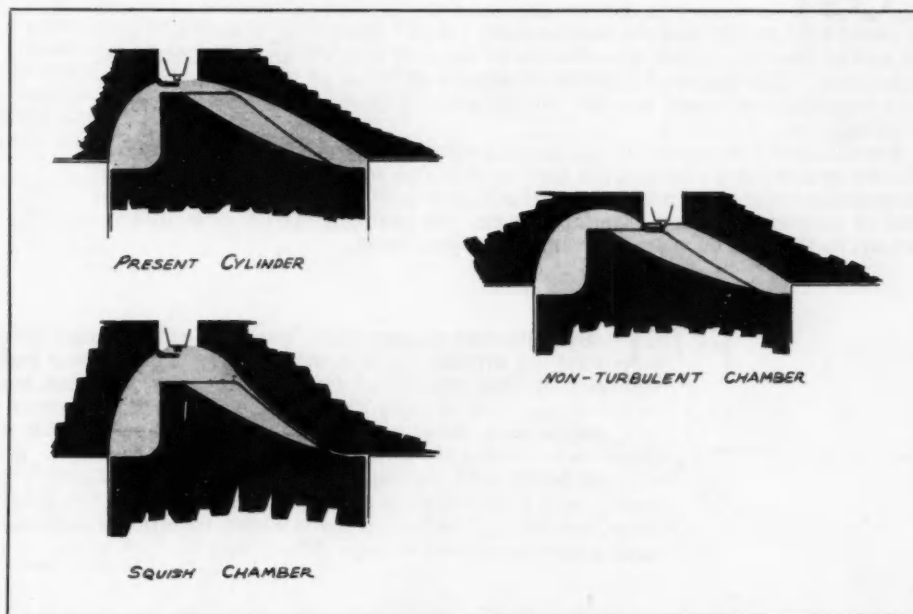
Spark timing of 40 deg of crank angle before top dead center gives minimum fuel consumption for part-throttle operation. To capitalize on this economy without sacrificing full-throttle performance:

- A third metering jet shoots fuel to the engine, and,
- Spark timing is retarded two or three degrees when the throttle is wide open.

third-fuel jet give good part-throttle . . .

# Engine Fuel Economy

Fig. 1—To increase pressure rise rate, the squish chamber increases turbulence. Fast burning also results from the short flame travel of the nonturbulent chamber.



These design improvements give the 40-hp engine better part-throttle fuel economy than the 33-hp engine running wide open. Part of the improvement results from reduced manifold pressures at part throttle. Closing the throttle cuts the force of the charge scavenging the combustion chamber. Less unburned fuel and air is blown out the exhaust port and fuel economy is improved.

A high rate of pressure rise in the combustion chamber is needed for variable spark timing and optimum burning of lean part-throttle mixtures. Two methods of forcing fast burnings tried are: increasing turbulence, and shorting the distance of flame front travel. Neither was completely satisfactory, but both have distinct advantages.

A squish chamber (Fig. 1) provides turbulence and gives smooth cycle-to-cycle operation. However, as the squish effect is increased, the power goes down.

This is due to relocating the spark plug to get it out of the way of the piston baffle—thereby increasing the flame front travel and leaving an unscavenged section which dilutes the charge.

Flame front travel is shortened by putting the spark plug in the center of the cylinder and reducing the height of the piston baffle. This design gives good part- and full-throttle power, excellent part-throttle economy, but terrible full throttle consumption. Lowering the baffle short circuits the scavenging by blowing the charge directly from intake to exhaust port. In addition, endurance tests show that spark plug life is short.

With this experience as a springboard, further designs are being tested. The present design is shown in Fig. 1.

To Order Paper No. S11 . . .

. . . on which this article is based, turn to page 5.

Here's how one engineer outlines . . .

# Requirements for Missile

Based on paper by

**R. D. Boyne**

Aircraft Accessory Turbine Department, General Electric Co.

**COST**—Procurement dollars to be spent on missile accessory power devices will rise steadily from the present \$50,000,000 to a peak of about \$165,000,000 per year in the early 1960's. After that, outlay will drop off and flatten out, reflecting a decline in manned aircraft and the missiles to arm them. This figure of \$165,000,000 covers all types of missiles and accessory systems—batteries, hot gas servos, turbine types, or whatever may be required.

Expenditure for research and development will rise correspondingly but lead by two or three years on the time scale. The yearly average for the next 10 years is estimated to reach \$7,000,000, not including cost of facilities or cost of proposal activity. Manufacturers will probably spend close to \$10,000,000 in the next 10 years just bidding on programs.

**FUEL**—Specific fuel consumption levels on units using liquid monopropellants are running around 10–12 lb per bhp-hr. These levels run somewhat higher for solid propellant devices, especially where there are significant load variations. Liquids have the advantage here of permitting a modulation of flow over a wider range than with solid fuels (solids have other advantages compensating for this in many applications). The problem is to reduce sfc levels below 10, perhaps to 6 or 7. Some progress has been reported, specifically with hydrazine, but much work remains to be done. Fuel slurries, for instance, have received little mention with respect to the MAPU. There are also the questions of fuel coking (carbon deposits which impair unit efficiencies) and polymerization (which presents serious storage difficulties).

**BATTERIES**—A target for power to weight ratios is 30 watt-hr per lb, especially in machines under 20 hp. Inverters must also receive attention. For example, a turbine-driven 10-hp machine delivering both hydraulic and electrical power (with about a 60–40 split, respectively) will weigh 6–7 lb per hp. A rotary type inverter for a battery system of the same rating would, in itself, weigh 11–15 lb per hp. However, in smaller all-electric units (ratings around 1 kva) the high proportion of alternator weight raises the ratio on turbine equipment to 20–25 lb per hp. This places the battery in a more competitive position, depending upon relationships between operating time, battery energy to weight ratio, and turbine unit sfc. Development of light weight, reliable static inverters obviously would have a major influence on the selection of battery systems.

**HOT GAS SERVOS**—These require a great deal of development work, especially in regard to lubrication. The decomposition products of monopropellants do not lend themselves to mixing with the more common lubricants. In units, response rates become troublesome.

# Accessory Power Units

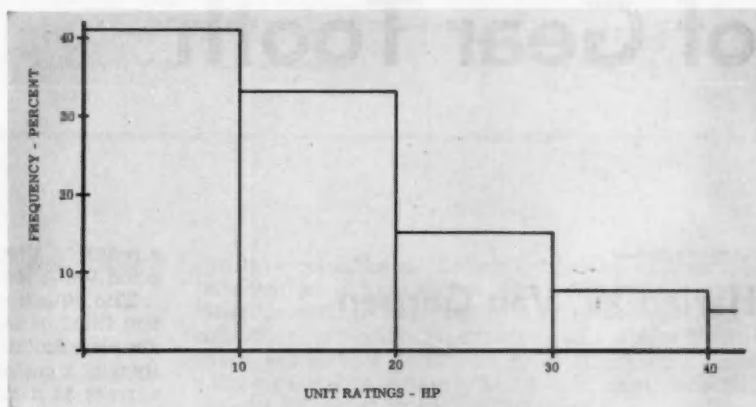
**POWER**—Today's power level requirements for MAPU's are shown in Fig. 1. About 40% of the units fall in the under 10-hp category, approximately 33% in the 10-20-hp class, and the balance in the 20-40-hp category, with a few going beyond the 40-hp mark. These figures reflect present missile capabilities. Most units in the under 10-hp classification have application in air-to-air missiles. As the use of air-to-air missiles declines and missile technology advances, a growth should take place in the percentage of units in the 20-hp class. The makeup of this power is primarily hydraulic and electric in roughly a 60-40 ratio. In a few applications, engine fuel pumping is added. With increases in missile Mach number and with continued emphasis on transistorized electrical circuitry, an increase in the ratio of hydraulic to electric power can be expected.

Specifications for a unit, expected to be typical in 1962, are given in Table 1.


**Table 1—MAPU Specifications—1962**

Rating, hp	15-20
70% hydraulic—3000 psi	
30% electric—1200 cps	
Duty Cycle, min	3-5
Control, %	Frequency $\pm \frac{1}{2}$
	Voltage $\pm 1$
Load	
Schedule	Power ratio 4/1
Unit Acceleration, sec	$\frac{1}{2}$
Weight (Dry), lb	75
Sfc, lb per bhp-hr	7
Environment:	
Storage	
Temperature, F	-65 to 160
Operating	
Temperature, F	-40 to 600
Vibration Scan	10g to 2000 cps
Acceleration	70 g
Altitude, ft	80,000

Fig. 1—About 40% of today's missile accessory power units have less than 10 hp. A rise in the percentage of units in the 20-hp category is to be expected when air-to-air missiles decline and missile technology advances.



**PUMPS AND ALTERNATORS**—The outstanding problem with driven accessories, pumps, and alternations is speed of operation. When we reach pump speeds of 30,000 rpm and obtain reliable operation, we will want 40,000 rpm. Judging by recent trends, alternator frequencies may be expected to move from 400 to 1200 cps in a number of applications.


**To Order Paper No. 215 . . .**  
 . . . on which this article is based, turn to page 5.

THIS REPORT on the use of a high-speed computer for determining the beam stress of gear teeth came to the attention of T. R. Thoren, Special Adviser to the SAE President on Computers. Thoren considered the topic of interest to SAE members—an example of the application of electronic computers in automotive engineering design. For that reason he submitted it through President Eddy with the recommendation that it be published in SAE Journal.

# High-Speed Computer Determines Beam Stress of Gear Tooth

Based on report by

**Harlan W. Van Gerpen**

Deere Mfg. Co.

**A**S high-speed electronic computers become available for engineering use, one of the problems profitably considered for computer calculation is the design of gears.

Most of the calculations in gear design involve following a set of basic data through a series of formulas and thus obtaining the design dimensions. There is, however, one part of the procedure which defies a simple mathematical solution. The usual practice is to make a large scale layout of the tooth profile in order to determine the Lewis formula  $Y$  factor and thus permit calculation of the maximum beam stress of the tooth. The problem in determining the  $Y$  factor is to find the point on the tooth profile which is tangent to a parabola originating at

a point on the centerline of the tooth where the applied tooth load crosses the centerline.

The equations describing the trochoid curve and the fillet of the tooth have been known. With no simple manual solution possible, the computer readily uses a cut and try or iteration procedure and thus arrives at a solution for the equations. The speed of the digital computer permits this type of procedure to be practical, requiring approximately 2 sec for a solution.

Corresponding to Fig. 1, which illustrates the situation for a basic rack with a full tip radius  $A$ , the rectangular coordinates of the point on the fillet  $F$  with respect to point  $P$  as an origin and tooth centerline as an axis are as follows:

$$m = R \sin(\theta_c + \alpha) \pm [\sqrt{d^2 + (Ra)^2} \mp A] \cos[\theta_1 - (\theta_c + \alpha)]$$

$$n = PO - R \cos(\theta_c + \alpha) \mp [\sqrt{d^2 + (Ra)^2} \mp A] \sin[\theta_1 - (\theta_c + \alpha)]$$

Where:

$$\theta_1 = \tan^{-1} \frac{d}{Ra}$$

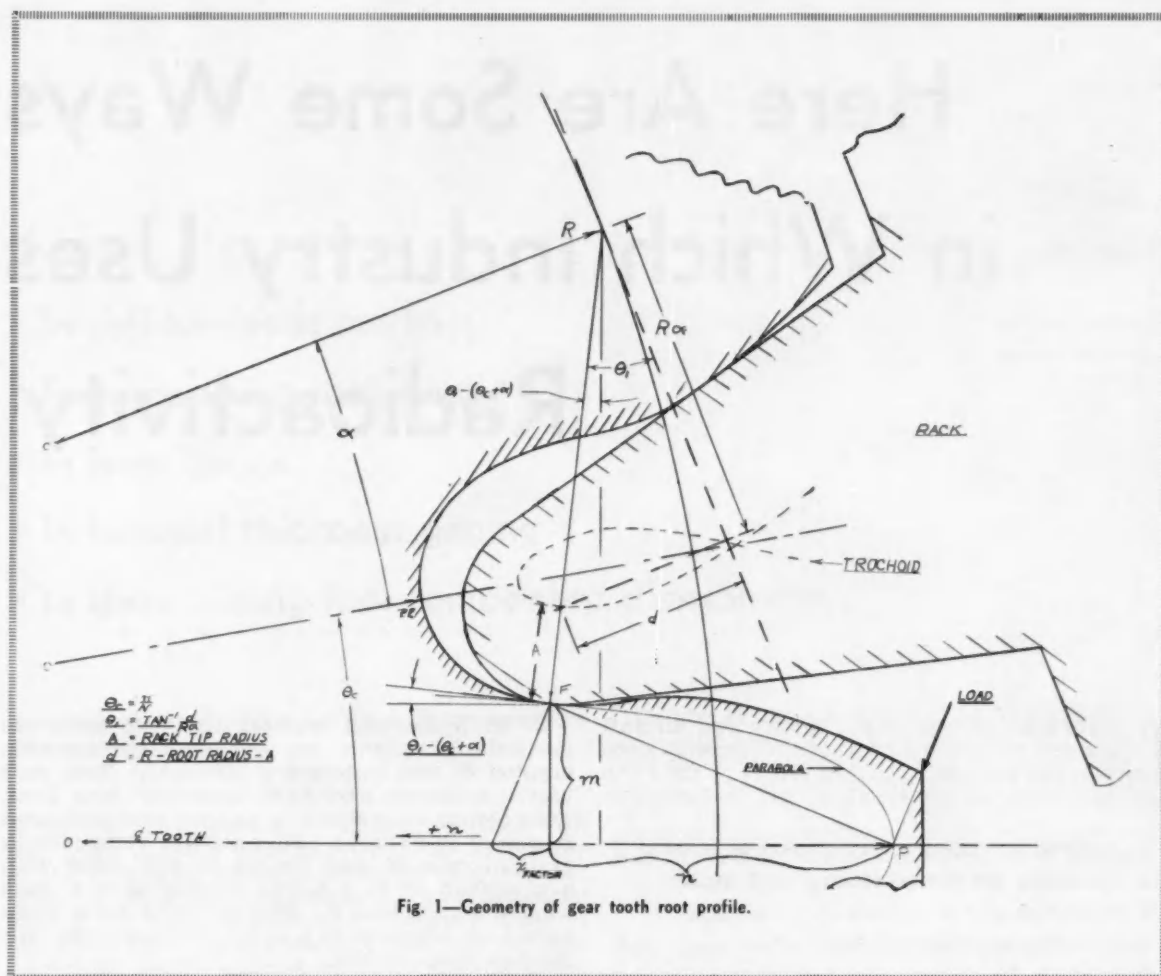


Fig. 1—Geometry of gear tooth root profile.

The slope at point  $F$  of a parabola originating at  $P$  and passing through  $F$  is equal to:

$$\text{slope} = \frac{m}{2n}$$

The slope of the fillet with respect to the centerline of the tooth is equal to:

$$\text{slope} = \tan [\theta_1 - (\theta_c + \alpha)]$$

When:

$$\frac{m}{2n} - \tan [\theta_1 - (\theta_c + \alpha)] \leq 10^{-5}$$

the point of tangency has been determined with sufficient accuracy. The only unknown,  $\alpha$ , is the variable changed by the computer in the iteration process.

The  $Y$  factor is then:

$$Y = \frac{2m^2}{3pn}$$

With appropriate change of signs, this set of equations holds for both curtate (bold signs) or looped

involute conditions. Difficulty will be experienced however as  $d$  approaches zero. The programmer must determine how small it may become before computer difficulty is experienced. Only a very small amount of error will exist if for very small values of  $d$  the magnitude of  $\alpha$  is kept zero and  $(\theta_1 - \theta_c)$  adjusted in increments until the condition of tangency is reached.

In selecting the initial iterative value it is desirable to make  $\alpha$  a function of  $d$  so that the direction of iteration ( $\pm \alpha$ ) will be selected automatically for either the looped or curtate conditions.

Not to be overlooked in determining the  $Y$  factor is the possibility of the point of tangency occurring on the involute profile. A check of the slope at the lower end of the involute profile, compared with the slope of a parabola passing through this point and originating at the center of load application  $P$ , will determine if parabola is overlapping the tooth profile and thus indicate a point of tangency higher on the tooth. Lack of overlap indicates tangency will occur on the fillet.

# Here Are Some Ways in Which Industry Uses Radioactivity:

**O**F particular interest to automotive and aircraft engineers are the following developments mentioned in the recently published report of the Fifth Annual Conference on Atomic Energy in Industry<sup>1</sup>:

1. Radioactive gases in self-luminous markers.
2. Tungsten 187 for measuring tool wear.
3. Cadmium sulfide crystals for beta gages.
4. Internal thickness gaging.
5. Carbon 14 for determining fuel component distribution in full-scale automotive engines.

## Self-Luminous Markers

Self-luminous markers containing radioactive gases already number among their many applications: illuminated aircraft flight boards, aircraft loading ramp markers, airfield ground equipment markers, landing strip markers, emergency exit markers, instrument switch illumination, and instrument scale illumination.

Luminous materials have, of course, been used for many years in such forms as the luminous dials of watches. These, however, have all employed solid radioactive sources and have been fairly faint in intensity. What was needed was a radioactive material of high activity, but little bulk, for which internal shielding would not be a problem. There should, moreover, be no health hazard, should the radioactive material be released because of an accident.

C. W. Wallhausen reported that two gases are particularly suitable for self-luminous markers: krypton 85 and hydrogen 3 (tritium). Both emit useful radiation and have relatively long lives. They require little shielding and are soon dissipated in case of an accident. They are now being used in gastight cells of glass coated on the inside with a phosphor, or in a metal housing with a glass window sealed into it. Sources using these gases have been prepared in a range of colors from blue through deep orange.

## Tool Wear

Tungsten 187 (24-hr half-life) has been used to detect as little as 1 microgram of tool wear, according to A. Somerville. (This is the amount normally encountered in 1-5 sec of cutting time.)

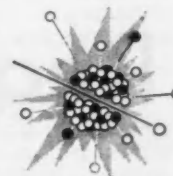
The tungsten 187 was incorporated in a tool for a 75-hp production-type lathe, especially designed for work with radioactive materials. Both the tool and the work piece were enclosed in a box that was exhausted through a filter system. The chips and the cutting fluid flowed through a hole in the box and were collected in a pail. They were then counted with a plastic scintillation crystal 7 in. in diameter.

## Beta Gages

Beta gages will become more popular, according to A. Somerville, thanks to the use of cadmium sulfide crystals as detectors. Although applied so far only to laboratory-type thickness and back reflection gages, their small size and extreme sensitivity indicate their great potentialities. (Extremely small crystals are as sensitive as an ionization chamber of average size.) For example, they

<sup>1</sup> Published by the National Industrial Conference Board, 460 Park Ave., New York 22, N. Y.

A feature of the



SAE Nuclear Energy  
Advisory Committee

- In self-luminous markers
- For measuring tool wear
- In beta gages
- In internal thickness gaging
- In determining fuel component distribution

are capable of detecting defects and irregularities in materials.

#### Internal Thickness Gaging

Internal thickness gaging contrasts strongly with the more familiar beta gaging, O. K. Neville reported. It is a technique of laboratory gaging rather than of elaborate manufacturing and industrial gaging. It can be used to study weathering of paint, oil films, lubrication problems, and platings and their ability to stand up under various treatments.

It consists in using a radioactive layer under the coating whose thickness is to be determined. For example, the effect of weathering and of washing rates on paint coatings can easily be studied by first laying down a layer of nickel 63, which emits very soft beta rays, and then painting over it. Absorption of the radiation by the paint provides an ideal method for determining the thickness of the paint after weathering, washing, or abrasion.

Sensitivity is extremely high. One can measure changes in film thickness of only a few micrograms per square centimeter. This gives better than 1% sensitivity, and on the order of 1% precision.

#### Fuel Component Distribution in Full-Scale Engines

Radioactive tracers, such as carbon 14, can now be used to measure accurately the distribution characteristics of the many experimental additives being tested for improving gasoline efficiency. This is done, as described by D. E. Cooper, by labeling some constituent in the base gasoline and then burning the fuel in the engine. The amounts of radioactivity found in the combustion gases, as sampled from the individual cylinders, are then compared.

Carbon 14, for example, can be incorporated into tetraethyl lead. It is then blended into the gasoline at normal concentrations (3 cc per gal) and fed into the engine under different sets of conditions. In one test of an 8-cyl engine the concentrations in the exhaust ran from 2.46 to 3.72 cc per gal. This is an unusually wide spread because of the conditions chosen for the test.

\* \* \*

#### Beta Gage Helps Make Better Storage Batteries

**M**ORE uniform thickness of the microporous rubber separators used in Delco automotive storage batteries is now being assured by the use of beta gages, according to Delco engineers.

As a result of this uniformity, the electrical characteristics of the separators are improved. This, in turn, makes it possible for the batteries to show higher terminal voltages.

The beta gage resembles an elongated C clamp. A radioactive source emitting a constant stream of beta rays is mounted in the bottom jaw of the clamp, with a detector unit directly opposite on the upper jaw.

Freshly rolled rubber sheeting passes between the source and the detector, with the detector counting the number of rays penetrating the rubber and translating this information into thickness measurements, which are recorded on a chart. Thick spots in the material allow fewer rays through to the detector unit, while thinner portions admit correspondingly greater numbers.

Thus, it is possible to detect and record thickness variations in a rapidly moving sheet of soft rubber as it flows from a calender roll. In a later operation the rubber is cut into proper sizes for battery separators. The device records thicknesses to 1/10,000 in. with an error of less than 1%.

# Requirements for the AIRPORT OF THE FUTURE

Based on paper by

**Martin A. Warskow,**

President's Aviation Facilities Planning Staff

**B**Y 1975 air traffic will have characteristics essentially as follows:

- (a) Air carrier traffic—a sizeable increase in plane movements over today with a steady growth in aircraft size.
- (b) Itinerant air traffic—a very substantial increase in aircraft movements with a high proportion of this being in aircraft weighing less than 10,000 lb.
- (c) Helicopter or STOL air bus or limousine growing until its volume of movement is about one-quarter the future air carrier traffic for large metropolitan areas such as New York.

This projected increase in aircraft movements indicates a need for healthy growth in our airport system. We should do all that is practical to increase the capacity of existing airports, and then plan ahead to provide additional airports as they are needed.

The installations needed at large airports to develop their maximum acceptance rate are reasonably well known.

To develop values for airport capacity, we can assume that: (1) the future airport would be equipped with these modern devices and installations; (2) the future air traffic control system could feed aircraft into the airport with a minimum spacing of two miles on final approach; (3) that a modest form of speed control would be used on final approach to regularize arrival over the wave-off point; (4) that the turbulence resulting from wing-tip vortices will permit the spacing of two miles;

and (5) a mixture of aircraft types operating from the airport will influence runway capacity.

## Large Commercial Transports

Based on these assumptions, the approximate IFR runway capacities are given below for a large commercial airport handling about equal volumes of large jet aircraft, large piston-engine or turboprop aircraft, medium piston-engine or turboprop aircraft, and a small quantity of slow transport-type aircraft:

Single runway—alternate landing and take-off: 50 movements per hr

Intersecting runways using one for landing and one for take-off in various combinations: 50–85 movements per hr

Physically separate runways but whose extended centerlines cross as an open V configuration using one for take-off and one for landing: 65–100 movements per hr

Parallel runways using one for take-off and one for landing: 75–100 movements per hr

## Small Itinerant Aircraft

Because of the volume of this traffic predicted for the future, special facilities are desirable which are designed to meet the operational needs of small itinerant aircraft. It appears that a large proportion of these aircraft will weigh less than 10,000 lb, require a landing and take-off area which is a max-

imum of 2500 ft in length, and have an approach speed which is less than 80 mph.

Runway facilities for small aircraft can be independent even though they are located on a transport airport. This will make the entire capacity of the main runway available for transport-type aircraft, and at the same time provide greater capacity to handle light aircraft while keeping them out of the areas of turbulence caused in the air by wing-tip vortices and on the ground by propeller jet blast. The added ground facilities will provide an appreciable overall increase in airport capacity.

Well-designed runways for light aircraft should have a capacity of 75-100 movements per hr. An exact prediction of this capacity cannot be made for little dependable data are available.

### Helicopters

Helicopters or STOL aircraft will generally be operating directly from one downtown facility to another downtown facility. However, a substantial number of helicopter and STOL movements will operate into airports.

Helicopter approach and departure paths into an airport should be completely isolated from fixed-wing approach and departure paths so that the operation is independent from fixed-wing activity.

If helicopters are so handled their operation at an airport should not affect its capacity for handling fixed-wing aircraft, and thus the addition of the helicopter again will make high-utilization of existing airport facilities.

### Aircraft Noise

The Federal Government can cooperate with the airport owners on aircraft noise and its effect on neighboring communities. This factor exerts tremendous influence on current airport design. It becomes increasingly important as air traffic grows, as airports approach capacity operation, and as the new jet aircraft are introduced into operation.

The airport planner can minimize the potential effect of noise by:

(1) Aligning runways to make maximum use of natural open areas, such as waterways and parks for approach and departure paths, consistent with operational considerations.

(2) Providing areas on the airport which, through location or construction of physical facilities, will keep ground runup noise level to a reasonable value.

The Federal Government should: (1) Encourage research to minimize the noise generated by both military and civil aircraft, and (2) consider the noise factor in adopting air traffic control procedures and making equipment installations.

The control of aircraft noise during landing and take-off operations must be accomplished in the manner which will permit maximum development of our present airport system. To assume that the

problem can be solved by moving airports out of developed areas is fallacious. The air traffic control system needed to feed airport complexes in large metropolitan areas will require that existing airports be expanded to their maximum, and that new airports be located far enough from existing airports to avoid conflict between approach and departure paths.

### Experimentation Needed

Examination of aircraft growth and its demand on airport facilities over the past years indicates a continuous growth in all airport facilities—particularly runways.

The Federal Government today does not have facilities for airport experimentation. Yet, study and experimentation is urgently needed on many basic airport design parameters.

Items such as the following need attention:

1. Determination of the separation required between parallel runways for various operating conditions, both VFR and IFR, and what is the resultant increase in runway capacity which can be expected under various spacings between runways and during various weather conditions.
2. Simulation studies and flight tests to determine more accurately maximum runway capacity and the minimum spacing of aircraft on final approach to the runway.
3. Development of standard visual signals for pilot/controller use.
4. Development and standardization of instrumentation for IFR approach and take-off of small itinerant multi-engine-type aircraft.
5. Determination of new procedures to feed at capacity a multiple airport complex with airports spaced as close as those in the New York area.
6. Determination of optimum runway configuration with regard to such physical aspects as high-speed turn-offs (their location, marking, configuration) and high-speed entrance taxiways for take-off.
7. Research and development to determine the visual aids necessary for properly marking large-radius, high-speed turn-offs and for the standardization of visual aids to approach and landing.
8. Review of existing airport design criteria.

To assist all phases of aviation in adequate development of the National Aviation Facilities System, government assistance is required in the form of accurate forecast data which will serve all segments of industry, thereby assisting the coordination of systems planning.

■ To Order Paper No. 100...

... on which this article is based, turn to page 5.

**Table 1—Comparison of Manual and Automatic Transmissions**

Each Transmission Paired on Same Route at Same Time of Day with Same Driver

Driver: Car:*	% Time Schwartz		% Time Salinger		% Time Newmark		Manual Transmission Average	Automatic Transmission Average
	P-8-M	S-8-A	P-8-M	S-8-A	F-8-M	C-8-A		
Total Acceleration	16.9	14.4	17.1	23.6	17.7	15.4	17.2	17.8
Road Load	55.1	38.3	51.8	28.5	41.0	28.6	49.3	31.8
Idle	5.9	25.6	11.0	22.1	17.6	19.7	11.5	22.5
Mild Deceleration	2.5	17.1	2.2	17.3	2.9	22.1	2.5	18.8
Rapid Deceleration	19.7	4.6	17.9	8.5	20.8	14.2	19.5	9.1
Total Deceleration	22.2	21.7	20.1	25.8	23.7	36.3	22.0	27.9
Average Speed, mph	24.0	20.5	22.2	26.6	21.5	23.5	22.6	23.5

\*P = Plymouth S = Studebaker F = Ford C = Chevrolet 8 = V-8 engine M = Manual Transmission A = Automatic Transmission

# DATA for DESIGNERS

Based on paper by

## Traffic Survey Panel,\*

Automobile Manufacturers Association

**I**NTERESTING relationships between design elements and existing driving habits and techniques were revealed in a recent survey of the traffic pattern in Los Angeles County.

Made by the Traffic Survey Panel of the Automobile Manufacturers Association, the study also provides data making it possible to simulate Los Angeles traffic on an automotive proving ground. In addition, it etches a clear picture of how the average Los Angeles driver operates.

### Transmissions and Hydrocarbons

The marked difference between manual and automatic transmission cars with respect to manifold vacuum was among the most interesting of the design element-traffic pattern relationships.

\* The Traffic Survey Panel consists of: D. M. Teague, Chrysler, chairman; W. Bishop, General Motors; L. H. Nagler, American Motors; G. Onishi, Studebaker-Packard; M. V. Sink, Chrysler; K. A. Stonex, General Motors; R. T. VanDerveer, Ford.

The differences, shown in Table 1 and Table 2, are significant, because a higher manifold vacuum results in poorer engine combustion, thus emitting more unburned fuel in the atmosphere. Automatic transmission cars, the report indicates, operating at a much lower percentage of the time in a condition of high manifold vacuum, should be a real benefit in decreasing the output of exhaust hydrocarbons.

These data were developed from recorded traffic flow statistics which included recognition of the fact that there is a large difference between operating patterns on various type routes.

(In this Los Angeles survey, for example, it was found that Freeway travel produced the least acceleration and deceleration . . . and the highest speed, gasoline economy, and road load time. Business section traffic, on the other hand, produced the highest idle time . . . and the lowest speed, fuel economy, and road load time. And, finally, travel in residential areas resembled business section travel, though to a lesser degree.)

### Simulated Traffic Pattern

The data to make possible proving ground tests on hydrocarbon emissions in Los Angeles driving have been set up as a series of test cycles. They very closely simulate a combination of all types of Los Angeles' traffic (Table 3).

A precise description is given of how a car should be driven. To represent acceleration, for example, the series lists the range of speeds to be covered, the

Table 2—Comparison of Manual and Automatic Transmissions

Sum of all Test Runs on Route 1 A

	Manual Transmission			Automatic Transmission		
	% Time	Mean Dev. From Mean	Standard Deviation	% Time	Mean Dev. From Mean	Standard Deviation
Total Acceleration	19.7	± 3.7	4.22	17.3	± 2.8	3.20
Road Load	38.6	± 9.0	10.32	34.0	± 5.8	6.58
Idle	19.2	± 6.9	8.58	20.0	± 3.7	5.02
Mild Deceleration	4.8	± 3.1	3.41	19.9	± 2.0	2.29
Rapid Deceleration	18.0	± 3.7	4.88	8.7	± 3.0	3.38
Number of Runs	16 (8 Drivers; 4 Different Cars)			9 (5 Drivers; 2 Different Cars)		
Average Speed, mph	22.0	± 1.1	1.40	22.9	± 1.2	1.62

According to this data, the difference between the manual and automatic transmission cars is statistically significant for mild deceleration and rapid deceleration.

## is plentiful in recent survey of Los Angeles County traffic pattern

rate of acceleration, and the percentage of total time which should be ascribed to each particular test.

### Los Angeles Driver

The picture of how a Los Angeles driver operates reveals:

- He spends about 15% of his driving time waiting for traffic lights or for traffic to move;
- About 16% of the time, he is moving at a nearly constant speed of about 30 mph;
- He's accelerating about 37% of the time;
- The remaining 32% of his time, he is decelerating.

Most of the time, the Los Angeles driver accelerates at part throttle. And, normally, he mixes acceleration, cruise, and deceleration many times from one traffic stop to the next.

He averages 23 mph for his trip. But he'll average about 49 mph on a freeway in light traffic; about 13 mph in downtown business traffic. And his fuel economy is similarly affected. It ranges from an average of 17 mpg for freeway travel in light traffic to 10 mpg in business section traffic.

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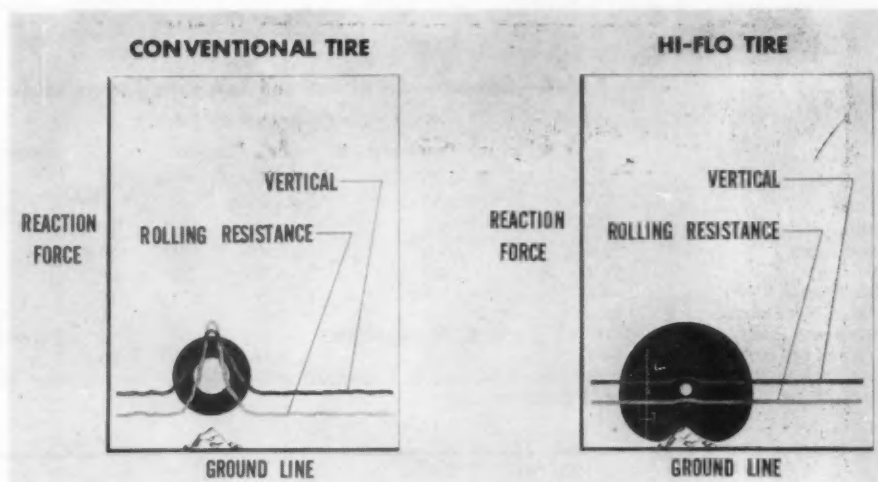
. . . on which this article is based, turn to page 5.

Table 3—Series of Recommended Driving Cycles, simulating conditions of car operation in Los Angeles

Condition	Rate of Speed Change mph/sec.	Percent Time
Idle		15.0
Cruise	> 0.2	
20 mph		6.9
30 mph		5.7
40 mph		2.7
50 mph		0.7
Total		16.0
Acceleration		
0-60 mph	3.0	1.1
0-25 mph	2.2	10.6
15-30 mph	1.2	25.0
Total		36.7
Deceleration		
50-20 mph	1.2	10.2
30-15 mph	1.4	11.8
30-0	2.5	10.3
Total		32.3

The results for each of the cycles specified above should be multiplied by the percentage indicated for that cycle. This will provide a total result for Los Angeles traffic.

Fig. 1—Low - pressure, high-flotation tires can handle inequalities in surface smoothness better than any other contact mechanism. Note the difference in rolling resistance.



## New Tire for STOL-Type May Permit Rough

Based on paper by

**V. Frisby**

Fairchild Engine & Airplane Corp.

**H**IGH-flotation tires, deflated in flight for stowing after each take-off and reinflated for landing, may be the answer to the problem of landing gear for STOL aircraft expected to operate without benefit of paved runway.

From the engineering standpoint, landing gear suitable for operation on unprepared fields must have characteristics differing greatly from those of a gear designed for use on level, or nearly level, paved runways, and used on aircraft with a large horizontal component of velocity on touchdown. There are perhaps four major points of difference between the two types of operation. These are:

1. The rolling resistance of conventional gear on pavements is a very small percentage of the vertical load on the gear, whereas on unprepared fields it may be a significant percentage of the vertical force, perhaps as much as one-half.

2. The rolling resistance on pavement may be essentially constant regardless of the speed. In contrast, the force opposing horizontal movement, the drag, of low-pressure tires on unprepared fields with soil of low shear strength may be expected to diminish with increasing speed.

3. The reaction of pavements to aircraft loads does not vary significantly with the moisture content of the soil of the countryside, whereas the re-

action of unstabilized soils is largely determined by moisture content.

4. The unprepared field is not a level, plane surface. Gear for use on unprepared fields must be ready to encounter protruding rocks, small stumps, bushes or corrugations resulting from cultivation, drainage improvements, erosion or action of the wind, and the like.

### Existing Gear Systems Unsuitable

Qualitative examination of all available gear systems, including those used or proposed in the past, which we made at the outset of this development project, showed not one meeting all the requirements for gear to be used on all types of unprepared fields. Then we conceived the idea that high-flotation pneumatic tires, operating at very low pressure, might meet all the requirements. They would have low rolling resistance on soils of low shear strength, either plastic or nonplastic, or at least such resistance would probably be less than that of higher pressure tires and probably less than the drag of skis. Moreover, the most attractive characteristic of the low-pressure, high-flotation tire is its superior accommodation to inequalities in surface smoothness. In this respect it is better than any other contact mechanism. The comparison is shown in Fig. 1.

Close consideration of using low-pressure tires on STOL aircraft indicated three probable difficulties. These were:

1. The tire would be so large that aerodynamic

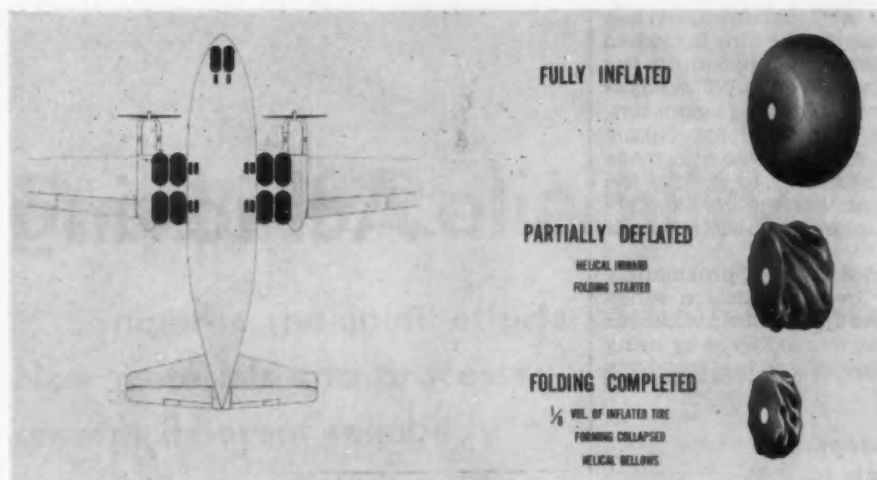


Fig. 2—To overcome aerodynamic drag during cruise, the tire will be deflated and folded for inflight storage.

# Aircraft Field Landings

drag might be unacceptable during cruise. The cure was to devise a means for deflating and folding the tires for inflight stowage, as shown in Fig. 2.

2. Low-pressure tires would have an undesirably large rebound from the deflection expected during the dissipation of the sinking speed during landing, and suppression of this rebound would require damping, as shown in Fig. 3.

3. The weight of low-pressure tires built by conventional methods would likely be unacceptably high. A remedy might be to use other tire fabrication techniques.

## Prototype Specifications

As the result of analytical studies, financed by the Transportation Research and Engineering Command of the Army, the feasibility of the project seemed assured and work was continued with the support of the Transportation Corps, U.S. Army. Specifications were drawn up for prototype tires of four rated loads—750, 1500, 4000, and 7500 lb. These tires would all be inflated to 17 psi before touchdown for a landing. When the load factor after touchdown reached a preset level, a vent valve would open in the system and the pressure and amount of air in the tires would become less and less as the footprint area of the tire built up.

The objective was to secure a constant product of footprint area times inflation pressure until the sinking speed reduced to zero, keeping this product as low as possible for the available deflection in the

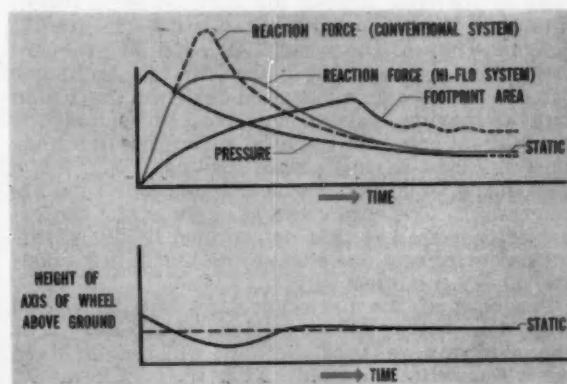


Fig. 3—Low-pressure tires would have an undesirably large rebound from the deflection expected during the dissipation of the sinking speed during landing. Suppression of this rebound will require damping.

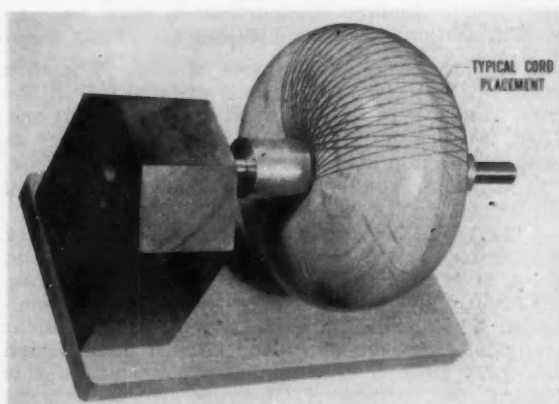


Fig. 4—A novel process will be used to build this low-pressure tire, using high tensile nylon and natural rubber. This model shows cord arrangement. Cord crossing angle at centerline of tread is that determined by great-circle course from one side of one hub to opposite side of other hub.

tire and the sinking speed at touchdown. When the quantity of air remaining in the tire furnished the desired pressure at optimum deflection for the rated load, the vent valves would close. The equations for this system, as solved by analog computers, predicted load factors well below four for sinking speeds up to 10 or 11 fps. Analysis was also made of oleo strut requirements necessary to provide the additional deflection in the system for sinking speeds up to 30 fps, with maximum load factors of four or less.

Tire weights were predicted to be approximately 1% of the rated load for a tire configuration which would give the deflection and footprint area needed for this system. This weight was achieved by using high tensile nylon and natural rubber in a relatively novel tire building process.

#### Method of Building Tire

The tire cord is wound into place in one continuous strand over a collapsible male mold, which remains in place until after the tire is cured. By varying the relative speeds of rotation of the male mold or mandrel during the cord winding procedure, any crossing angle desired can be secured at the centerline of the tread. All cords are tangent at the hub or bead of the tire. By this technique it is hoped to secure a balanced design in the tire in that the maximum stress in all cord throughout the tire is about equal for the most severe tire deformations expected during service loadings. Fig. 4 is a photograph of a model which shows this cord arrangement. The cord crossing angle at the centerline of the tread is that determined by the great-circle course from one side of one hub to the opposite side of the other.

The cord of the prototype tires will be coated with hot, sticky, green rubber just before it is wound into place, thus the cord will remain fixed where it touches the mold. After the cord is wound into place and the tread, if any, applied, it is intended to wrap the assembly with nylon or dacron tape, using the same machine which winds the cord, and then place the tape-wrapped, uncured tire into an autoclave for curing. The mold will be collapsed and removed through the hub after curing.

#### Anticipated Testing

It is planned to test in two phases. The first phase will determine the stress distribution in the tires under service loadings and deformations. When the tire design appears to be satisfactory as regards direction and density of cord in the carcass, with minimum rubber, the second phase of testing will determine the behavior of the tire in service.

If the results of the second phase of testing are as anticipated, we will recommend dynamic testing of the tires in combination with the vent-valving and folding mechanism. When these tests are successful and additional data on soils of low shear strength have been obtained, we will have design data for a landing gear system which will make it possible to operate STOL-type aircraft almost worldwide without dependence upon prepared runways.

**To Order Paper No. 220 . . .**

**. . . on which this article is based, turn to page 5.**

# Achieving

Based on secretary's report by

**A. C. Rohde,**  
American Airlines, Inc.

**A**LTHOUGH accelerated service testing and quality control are valuable aids in establishing product reliability, what is needed now are new materials and processes to ensure greater reliability than ever before. To retain built-in reliability, operators must determine proper maintenance procedures and schedules, retain experienced trouble-shooting personnel, and perform periodic inspections.

Product reliability must initiate on the drawing board. The engineer who designs a unit must look beyond just a workable piece of equipment. He must know and understand the application of the unit, its effect upon safety, cost, and the operational reliability of the aircraft with which it is being used.

The unit must then undergo accelerated service tests—not merely some cycling test to see how many times it can be turned on and off, or how many times it can be oscillated or vibrated, or how it functions at minus  $x$  degrees or plus  $y$  degrees, but a combination of all of these as they apply to the operating conditions to be encountered. To really prove reliability, these tests should be evaluated on the basis of total time equivalents for single units—not the misleading accumulative figure of many units used so commonly today. If the tests today were really evaluated they would almost certainly prove many units totally unreliable.

Quality control is another aid in achieving product reliability. But to be successful, control must extend through materials, processing, machinery, jigging, assembly, and testing. Without quality control product reliability cannot be attained; conversely however, quality control on a poorly designed unit is no help toward obtaining reliability.

Scientific research for new and better materials appears to need bolstering. Better materials are not only needed for the manufacture of products

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# Product Reliability . . .

. . . requires the joint efforts of both manufacturer and user. New materials and processes are needed, however, to provide greater inherent reliability.

but also for tooling. It is generally conceded that good tooling is a prime requisite in producing a reliable product.

Running hand in hand with the shortcoming in materials development is the need for new and better processes, such as bonding methods, cutting, forming and joining processes. Also needed are coating processes for protection against corrosion, heat, and such. It should be understood that while progress is being made along most of these lines, it is the consensus of most manufacturers that new developments in materials and processing are lagging behind the progress being made in other phases of the aviation industry. Much effort will have to be expended if reliability is to improve at the same pace with performance.

To maintain the reliability built into a unit by the manufacturer, operators must determine proper

maintenance procedures and schedules for the unit. They must also retain experienced trouble-shooting personnel to service this equipment. One device which would aid in relieving the current shortage of experienced troubleshooters, especially on jet and turbo-type engines, is an engine data recorder. One that will record the pertinent and basic engine operating data such as fuel flow, temperature, thrust, and rpm. This unit should be so designed that when predetermined limits of any one of the items being monitored are exceeded, the recorder would automatically start operating. The unit should also record time periodically so that a reviewing expert could determine the rate of progression of any difficulty. Such a device would allow the operator to present accurate performance data to his experts and to compile histories on engine difficulties.

One step in determining and establishing reliability which has already taken hold with operators is the use of x-rays in conducting structural inspections of aircraft. Previously, many manhours were expended in opening up and closing stressed inspection openings. Through the application of straight x-rays, some operators have reduced this unnecessary labor considerably. Of course considerable experiences and development are still needed to assure that angles, distances, and power are right for the area being filmed and this is being done.

Nuclear radiation holds considerable promise for the same application and offers the advantage of not requiring electrical power for operation. Both of the methods, however, are only good for locating incipient cracks either from inclusions within the material or stress risers and notch effect—in other words, after a failure has started.

The diffraction x-ray offers one of the most revolutionizing processes industry has encountered. One manufacturer has developed a portable unit which appears to offer great possibilities in measuring fatigue and inspecting the molecular structure of materials. If proven successful, the science of metallurgy will have experienced a breakthrough.

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## THE EXPERTS . . .

. . . serving on the panel "Product Reliability" were:

**W. N. Phillips**, panel leader  
Aircraft Armaments, Inc.

**A. C. Rohde**, panel secretary  
American Airlines, Inc.

**K. F. Wazmuth**  
Republic Aviation Corp.

**T. L. Taylor**  
Engineering, Inc.

**A. Schmelling**  
Lavoie Laboratories

**E. C. Sedlack**  
Westinghouse Electric Corp.

**M. Whitlock**  
American Airlines, Inc.

**B. L. Brown**  
Grumman Aircraft Engineering Corp.

**To Order SP-319 . . .**

... on which this article is based, turn to page 5.

# Aircooled Diesel Compares with Liquid-Cooled Type in Important Aspects

Based on paper by

**C. F. Bachle,**

Continental Aviation and Engineering Corp.

**I**MPORTANT considerations in comparison of air- and liquid-cooled diesel engines are:

1. Plumbing difficulties.
2. Antifreeze requirements.
3. Bulk—hp/cu ft.
4. Weight—lb/hp.
5. Fan power and quantity of cooling air required.
6. Noise.
7. Costs.
8. Operation and maintenance.

A discussion of the relative merits of each type of cooling system with regard to these eight points is summarized in Table 1.

**Plumbing Difficulties:** Elimination of plumbing difficulties is an obvious advantage of aircooling. Liquid-cooled engines for military purposes have as many as 40 hose clamp connections, the average V-8 passenger car or truck engine has 12, and each of these is a potential point of leakage. In addition, liquid-cooled engines have cylinder head and liner gaskets which, together with water pump, plugs and other gaskets, constitute hundreds of places for leakage trouble.

The leakage disadvantage of the liquid-cooled engine is offset by the sheet metal problem associated with the aircooled engine, although the sheet metal does not require tight joints. The attaching and stiffening methods must be worked out carefully to get long life and ease of assembly.

**Antifreeze Requirements:** Some fleet operators are so concerned with the uncertainty of ordinary antifreeze protection that they prefer to drain the cooling system completely in cold weather rather than run the risk of a freeze-up. Others allow the

engine to idle for hours so that it never can cool down. Moreover, liquid-cooled engines suffer from corrosion and clogging of the radiator and cooling system. The incentive to use aircooling really stems from this antifreeze problem coupled with plumbing difficulties and the aircooled engine has the advantage here without offsetting disadvantage.

**Bulk:** Cylinder wall thickness and the liquid-cooling space between cylinder bores ordinarily dictates cylinder spacing. Aircooled engines require considerably more space between cylinder bores because of the necessary height of the fins. This makes the overall length of the engine greater. However, the length differential between the two types is being reduced by trends to high bmep because the large boost in specific output demands stiffer hence larger crankshafts in proportion to cylinder bores. As a result, crankshaft and crankcase structure rather than cylinder bores now dictate cylinder spacing of both types of engines.

Three classifications of use can be seen:

1. For high performance applications, such as in armored fighting vehicles, the liquid-cooled engines may be slightly smaller, but when cooling system and ducts are added for desert cooling the package turns out to be considerably larger than the aircooled one.

2. For moderate performance applications, such as trucks and earthmoving machinery, the more compact liquid-cooled designs are often selected where bulk between air- and liquid-cooled engines may be similar.

3. Low output industrial applications. The aircooled power package is undoubtedly larger, but bulk considerations are likely to be unimportant when balanced against trouble-free running, availability of coolant, and other advantages.

**Weight:** Aircooled engines tend to be lighter because of the necessary extensive use of aluminum, but this margin partially disappears if liquid-cooled engines are designed with a similar policy and material use. When radiators and coolants are included

in the weight analysis, liquid-cooled engines are usually found to be at a slight disadvantage.

**Fan Power and Cooling Air Required:** Aircooled engines are commonly misconceived to use more power for cooling and a higher volume of air than liquid-cooled types. The reverse is usually found in military applications, whereas commercial applications are usually about equal for both types.

Fig. 1 shows typical temperatures measured on a 5¾-in. bore aircooled diesel manufactured by Continental. If the median temperature of the fins is taken as 260 F and the ambient air on a hot day is 125 F, the temperature differential between the metal and the cooling air is 135 F. This compares with a differential of only 55 F between the radiator (180 F) and the cooling air of liquid-cooled military engines if no pressure system is used.

There are advantages in operating a liquid-cooling system under pressure because the temperature differential between coolant and air is increased. The military are generally opposed to pressure systems because of the great problem of sealing and the danger of losing all coolant if the pressure valve pops open. Common practice in certain commercial applications is to use pressure systems of 4 to 7 psi (corresponding to temperatures of 224 to 232 F), then the air flow and cooling power for the liquid-cooled approaches the values of the aircooled type.

The military as opposed to the industrial engine is designed with wide ambient temperatures in mind since the standard hot day is specified at 125 F ambient and the engine compartment temperature can then be 140 F, but with modern airborne equipment this same vehicle could, inside of a few hours, be transported to the Arctic with temperatures of -65 F, or lower. For temperatures below 60 F the liquid-cooled system has advantage over the aircooled, but the full advantage cannot be enjoyed because the present-day antifreeze will begin to slush at -65 F (Fig. 2).

On the high temperature side, an increase in weight of about 50% occurs in the liquid-cooled system if an ambient temperature of 120 F is to be en-

Table 1—Comparison of Air- and Liquid-cooled Engines

	Military Vehicles	Commercial Vehicles
	Advantage for Air	Advantage for Liquid
1. Plumbing Difficulties	X	
2. Antifreeze Requirements	X	X
3. Bulk, hp/cu ft	X	Equal
4. Weight, lb/hp	X	Equal
5. Fan Power and Quantity of Cooling Air Required	X	Equal
6. Noise		X
7. Costs	Equal	Equal
8. Operation and Maintenance	X	X
9. Lubricating Oil Cooler	Equal	Equal
10. Lubricating Oil Cleanliness	X	X
11. Net Specific Fuel Consumption	Equal	Equal
12. Cylinder Wear	Equal	Equal

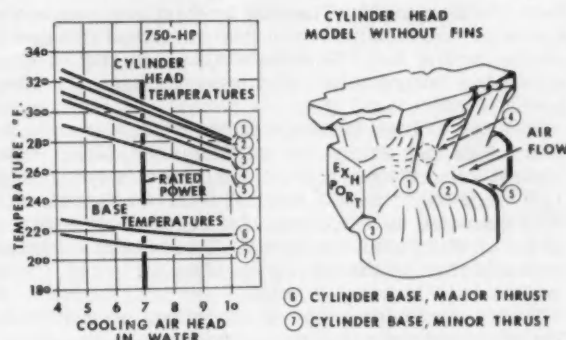


Fig. 1—Typical temperatures measured on a Continental 5¾-in. bore, aircooled diesel engine.

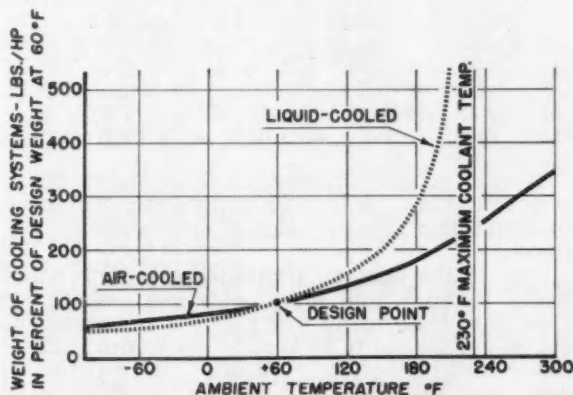


Fig. 2—Relative change in weight of cooling system for an engine of constant output as the coolant temperature is varied for each type of coolant, based on each being called 100% at the design point of 60 F.

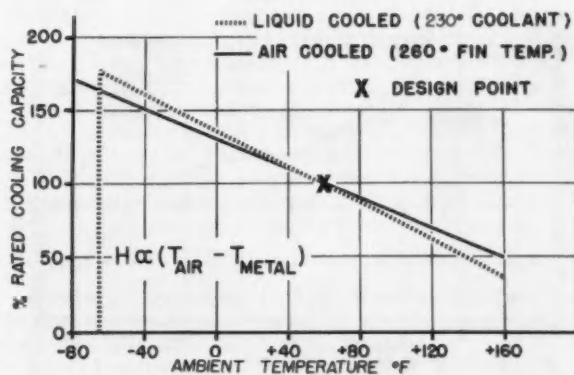


Fig. 3—Variation in cooling capacity of aircooled and liquid-cooled engines from the standard design day of 60 F ambient to the extremes of cooling air ambient temperature of -65 to 120 F.

countered. The aircooled engine requires only about 30% increase in weight of the cooling system for the same ambient temperature.

Fig. 3 shows the variation in cooling capacity for the two systems from the standard design day of 60 F ambient to the extremes of cooling air ambient temperature of -65 to 120 F. If both cooling systems are designed for 100% capacity at the same ambient temperature, the one having the highest metal temperature in contact with the cooling air will also have the highest reserve when the cooling air temperature increases. The liquid-cooled engine with its maximum temperature of 230 F (pressurized) at the radiator can only cool at 65% of its designed capacity on a 120 F day, while the aircooled engine still has 70% of its capacity. These conditions are by no means extreme. We design engines with adequate cooling capacity for ambient temperatures of 140 F. This increase in capacity is small, but there are installations where it can become quite important.

Under arctic conditions where ambient temperatures are extremely low, various devices are used to avoid penalizing the aircooled system. A thermostat may be installed to provide for recirculation of the cooling air just as the liquid is recirculated in the liquid-cooled type. And shutters to control or limit the flow of air are used. The best method is to provide a speed control mechanism to stop or control the speed of the cooling fan. This maintains a correct engine operating temperature and also reduces the fan power losses.

The use of high pressure drops in cooling air systems does not imply low performance fans. One typical assembly has a 25-in. tip diameter fan with a 15½-in. hub, or a hub ratio of 0.62. It operates at 5600 rpm and moves 15,000 cfm of 240 F air against 13 in. of water static pressure. The maximum axial width of the fan rotor is 2.4 in. (Fig. 4).

**Noise:** Aircooled engines are often noisier than liquid-cooled ones, frequently because of fan noise. In military installations of aircooled engines, half of the fan pressure differential is ordinarily used in overcoming the duct system resistance and the other

half for pressure drop across the cylinders. This demands high fan tip speed which is conducive to high noise. One way of greatly reducing this fan sound is to space the fan blades unevenly.

Noises produced by the valve gear, piston slap, and fuel injector are essentially equal in the two types of engines. A minor advantage accrues to the liquid-cooled system from the damping of some sound by the water layer and extra metal wall.

**Costs:** We have found little, if any, cost differential between liquid- and air-cooled engines given identical conditions. The point can be made that there is very little difference in cost per horsepower.

Since 50% of the weight of the aircooled engine is comprised of parts of the same type and workmanship as found on the liquid-cooled engine, comparison will show equal cost for this much. The accessories comprise an additional 10% of the engine weight and the same type can be used on either engine. This leaves 40% for comparison of cost. Our aircooled engine has aluminum cylinder head and crankcase in contrast to cast iron for the liquid-cooled. Aluminum is more expensive on a per pound basis, but that does not mean extra cost. Aluminum parts equal in strength to cast iron are usually lighter and more economical to machine, hence often lower in cost. Scrap losses are usually less since with the individual cylinder construction of the aircooled type, one defective spot does not condemn five good cylinders. The size and design of many aircooled engine parts permit casting by permanent mold or die casting which can yield still further economies.

Individual cylinder construction permits the economical application of automation to production at a smaller engine unit rate than would be the case with the enblock design. This coupled with the smaller size of the cylinder unit leads to automation with all its benefits.

Actually, the cost of aircooled vehicle engines when produced at low yearly rates may be equal to and, at high yearly rates, less than the cost of an equivalent liquid-cooled engine with its cooling system on a dollars per horsepower basis.

**Operation and Maintenance:** Aircooled engines usually warm up quicker and operate with higher cylinder wall temperatures at light load than do the liquid-cooled. The reduced warm-up period is an advantage in cylinder bore wear and helps reduce the chances of fuel or condensation contaminating the lube oil and forming acid or sludge. This is especially valuable when operating with high sulphur content fuels.

Tests show fuel consumption to be unaffected by type of cooling. It is more importantly influenced by such things as combustion principles and friction losses.

It is to the operator's advantage to omit water pump, radiator, and many seals and gaskets. It frees him from many interruptions in service, no spares are needed to be kept in stock, and maintenance and replacement are nil. The omission of water and antifreeze is of obvious benefit in many applications.

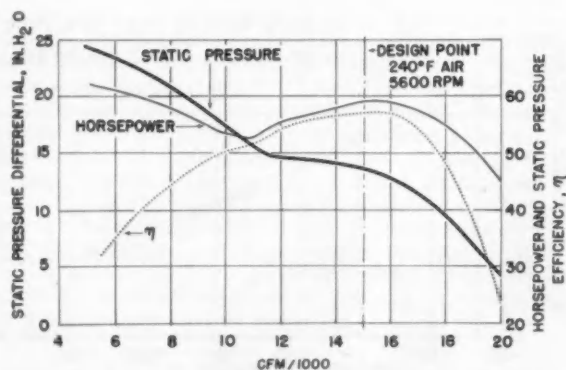


Fig. 4—Performance of typical aircooled engine fan. Here is the wind tunnel performance of the fan rotor at 5600 rpm. Note comparatively flat static pressure performance curve at the design point.

**To Order Paper No. 154 . . .**  
 . . . on which this article is based, turn to page 5.

# Blasting with 3-Micron Particles

**Suspending small particles in water extends peening and blast cleaning techniques.**

**F**INE particle blasting is an extension of shotpeening or grit blast cleaning. The problems of handling a very fine abrasive have been overcome by suspending them in water or air.

The big brother particles are fed to shotpeening machines by gravity. As the size of the particles goes down they don't flow as easily (the angle of repose increases) and the machine clogs. However, as the particle size goes down, the ability to suspend abrasive in water (or air) goes up. The abrasive can then be fed through a nozzle and blown at a part with compressed air.

## Using Fine Particle Blasting

Cleaning, metal removal, and polishing are the uses of fine particle blasting. The particular effect depends on the type and size of particle, the material being blasted, and the exposure conditions.

- Cleaning ranges from taking paint off glass to scale removal. The operation is faster than pickling and the surfaces are left metallurgically clean. There is no hydrogen embrittlement. The surface roughness can be controlled to original tolerances by the correct selection of abrasive size. Complex configurations such as hobs and broaches and all types of dies can be cleaned and polished rapidly. In the case of dies the surface can be made a matte finish which will hold oil and lubricate the die.

Inspecting for cracks is easy with fine particle blasting as the fissures and cracks are quickly cleaned out and shown up.

- Metal removal is limited to fine cuts. Small burrs can be removed but large radii cutting is impractical. Fine cuts are useful in mating close fitting parts since remounting a part in a machine for an extremely fine cut is often impossible.

Experience to date shows nonferrous metals harder to cut than steel alloys. In fact, lead appears almost resilient to the blasting action. Soft metals are apparently more critical of the type of abrasive. One test shows that rounded (glass beads)

or large (quartz and aluminum oxide) particles do not cut an aluminum strip. In the first case the aluminum was peened and in the second it was locally upset, producing "peaks" which made the strip measure thicker.

- Surface finish control works both ways. Blasting will roughen or smooth a surface depending on the original surface and the size of abrasive.

Practical limits of surface roughness are from 5 to 180 microin., rms. In the first case this limit is possible if the original surface was this smooth. Reducing surface roughness is most profitable in the 40 to 20-microin. range. Proper particle selection will cut the roughness from 40 to 20.

A blasted surface is ready for difficult coating jobs. For example, chrome can be plated directly on aluminum if the part is kept in deaerated water after wet blasting.

Cast iron will end up rougher after blasting. When machined or polished, fine cast-iron dust fills in the natural voids in the metal. Blasting cleans out these holes causing high readings of surface roughness.

## Abrasives Used

Natural and synthetic abrasives are used. Silica, quartz, and novaculite are typical of the first while aluminum oxides and silicon carbides are common synthetic abrasives.

Hardness, body strength, and low attrition are needed in any abrasive. The first insures good cutting, while the second prevents fracturing into too small sizes. Attrition is the tendency for the abrasive to dissolve or diffuse into the metal being cut. This property corresponds roughly to metal-and-abrasive dissolving rate in a state of fusion.

The finest abrasive is novaculite, a siliceous rock found in Arkansas. It has a fineness of "5000" mesh, which is  $2\frac{1}{2}$  microns, up to 140 mesh (105 microns). The largest particles practically used in wet blasting are in the range of 60 to 80 mesh. Below the 37-micron size measurements are made visually since this is the smallest size that has a standard sieve specified by the Bureau of Standards.

## Wet Suspension

The flow of a fine abrasive through a blasting machine was solved by suspending it in water. However, three new problems are introduced: the packing of the abrasive into cakes or aggregates, rusting of the parts being blasted, and the removal of abrasive from the part after contact.

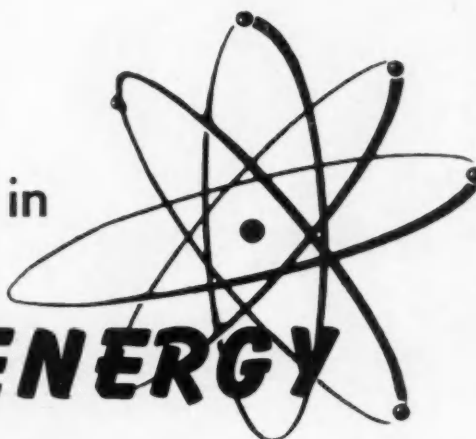
These were solved by adding chemicals to the water. A wetting agent keeps the abrasive flowing over the part, a rust inhibitor protects the part until finally treated, and a dispersion agent makes the particles repel each other. The last also aids uniform distribution of abrasive in the water.

Excerpts from a Fine Particle Blasting Symposium held at a meeting of Division 20, Shotpeening, of the SAE Iron and Steel Technical Committee.

Panel Members: H. J. Noble, Pratt & Whitney Aircraft Division, Moderator; W. I. Gladfelter, Pangborn Corp.; E. E. Hawkinson, Microblast Mfg. Corp.; Steve Kundrach, Warner & Swasey Co.; A. A. Liene-mann, Vapor Blast Mfg. Co.; and D. D. Sandy, Ford Aircraft-Engine Division.

## Selected Readings in

# ATOMIC ENERGY



Suggested by the  
SAE Nuclear Energy Advisory Committee

**L**ITERATURE on atomic energy continues to pour forth at a prodigious rate.

The SAE Nuclear Energy Advisory Committee makes available, from time to time, selected readings in various phases of the subject that might be of particular interest to SAE Journal readers.

This list is a supplement to the one given in the October, 1956, issue of SAE Journal, pages 45-47.

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**Atomic Energy Applications with Reference to Underdeveloped Countries.** B. C. Netschert and S. H. Schurr. Baltimore, Johns Hopkins Press, 1957.

**Prospects of Nuclear Power and Technology.** Gerald Wendt. New York, van Nostrand, 1957.

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**Special Report on Nuclear Energy.** SAE Journal, Vol. 65, February, 1957, pp. 41-69.

**Coming Nuclear Industry.** H. E. Anderson. *Chemical Engineering*, Vol. 63, December, 1956, pp. 191-210.

**World Look at Usefulness of Nuclear Power.** W. L. Cisler. *Electrical Engineering*, Vol. 75, 1956, pp. 409-412.

**Will Atomic Energy Replace Oil?** R. E. Wilson. *Petroleum Refiner*, Vol. 35, November, 1956, pp. 118-119.

### Atomic and Nuclear Physics

**Annual Review of Nuclear Science**, Vol. 6. Palo Alto, Calif., Annual Reviews, Inc., 1956.

**Progress in Nuclear Energy.** Series I. Physics and Mathematics. New York, McGraw-Hill, 1956.

**Handbuch der Physik**, Vol. 36, Atoms II. S. Flügge, editor. Berlin, Springer-Verlag, 1956.

### Reactor Physics

**Physics of Nuclear Reactors.** Supplement No. 5, British Journal of Applied Physics. London, Institute of Physics, 1956.

**Reactor Shielding Design Manual.** T. Rockwell. New York, McGraw-Hill, 1956.

### Chemistry and Chemical Engineering

**Progress in Nuclear Energy.** Series III. Process Chemistry. New York, McGraw-Hill, 1956.

**Atom's Role in Chemical Industry.** *Chemical and Engineering News*, Vol. 34, Feb. 27, 1956, pp. 919-921.

**Atomic Energy and Petroleum Industry.** A. C. Johnson. *American Petroleum Institute Proceedings*, Vol. 35, 1955, pp. 117-121.

**Chemical Engineering Progress' Special Review of Nuclear Engineering.** *Chemical Engineering Progress*, Vol. 51, October, 1955, pp. 437-484.

**Mixing the Atom with Coal; Synthesis Gas Production.** *Chemical and Engineering News*, Vol. 34, Dec. 24, 1956, pp. 6284-6286.

**Producing Chemicals with Reactor Radiations.** P. Harteck and S. Dondes. *Nucleonics*, Vol. 14, July, 1956, pp. 22-25.

**Chemical Processing in Nuclear Power Industry.** F. S. Martin and G. L. Miles. *Atomics*, Vol. 7, 1956, pp. 14-23, 52-58, 61, 79-87, 110.

### Reactor Technology

**Nuclear Power Reactors.** James K. Pickard. New York, Van Nostrand, 1957.

**Progress in Nuclear Energy.** Series II. Reactors. Series IV. Technology and Engineering. New York, McGraw-Hill, 1956.

**Characteristics of Nuclear Reactors for Power, Production of Nuclear Fuel, and Irradiation of Materials.** *Product Engineering*, Vol. 27, May, 1956, pp. 138-147.

**Symposium: Calder Works Nuclear Power Plant.** *Journal of British Nuclear Energy*, Vol. 2, April, 1957, pp. 41-228.

**Economics of Small Nuclear Power Units.** J. M. Kay. *Nuclear Engineering*, Vol. 1, September, 1956, pp. 225-227.

**Fundamental Aspects of Nuclear Reactor Control.** M. A. Schultz. *Westinghouse Engineer*, Vol. 16, May, 1956, pp. 74-79.

**Thermal Power from Nuclear Reactors.** A. S. Thompson and O. E. Rogers. New York, Wiley, 1956.

### Waste Disposal

**Sanitary Aspects of Atomic Energy Industry.** Seminar Sponsored by AEC and Public Health Service, Held at Robert A. Taft Engineering Center, Cincinnati, Ohio, Dec. 6-9, 1955. *U. S. Atomic Energy Commission Report TID-7517*. Available from Office of Technical Services, Washington, D. C.

**Long-Term Aspect of Fission Product Disposal.** E. Glueckauf. *Atomics*, Vol. 6, September, 1955, pp. 270-276, 281.

**Ground Disposal of Radioactive Wastes.** R. J. Morton and

E. G. Struxness. *American Journal of Public Health*, Vol. 46, February, 1956, pp. 156-163.  
**Radioactivity in Stream Pollution.** R. C. Palange, G. G. Robeck, and C. Henderson. *Industrial and Engineering Chemistry*, Vol. 48, October, 1956, pp. 1847-1850.  
**Economics of Waste Disposal.** H. R. Zeitlin, E. D. Arnold, and J. W. Ullmann. *Nucleonics*, Vol. 15, January, 1957, pp. 58-62.

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**Progress in Nuclear Energy.** Series V. Metallurgy and Fuels. New York, McGraw-Hill, 1956.  
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**Nuclear Radiation Effects in Solids.** H. Brooks. *Annual Review of Nuclear Science*, Vol. 6, 1956, pp. 215-269.  
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**How Radiation Affects Petroleum Lubricants.** *Power*, Vol. 100, December, 1956, p. 164.

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**Machines Give Cheaper Radiation.** C. H. Stockman and R. G. Bauman. *Chemical and Engineering News*, Vol. 35, Aug. 5, 1957, pp. 16-21.

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**Progress in Nuclear Energy.** Series VIII. Economics of Nuclear Power including Administration and Law. New York, McGraw-Hill, 1956.  
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**Proceedings of Summer Institute on Legal Problems of Atomic Energy.** Ann Arbor, University of Michigan Law School, 1956.

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**Profits from Nuclear Power.** M. Michaelis. *Harvard Business Review*, Vol. 34, 1956, pp. 99-115.

**Atomic Energy and the Investor; New Investment Area Seen.** G. M. Gadsby. *Trusts and Estates*, Vol. 95, 1956, pp. 819-821.

**Nuclear Energy and Its Products Appearing in Wide Variety of Industries; Excerpts from Stockholder Reports of 89 Corporations.** *Trusts and Estates*, Vol. 95, 1956, pp. 649-658, 732-734.

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**Safety Aspects of Nuclear Reactors.** C. Rogers McCullough. New York, Van Nostrand, 1957.  
**Radiation Dosimetry.** G. J. Hine and G. L. Brownell. New York, Academic Press, 1956.  
**Control of Radiation Hazards in Industry.** Prepared and published by N. Y. State Department of Labor. Available from Dr. Morris Kleinfeld, New York State Department of Labor, Division of Industrial Hygiene, 80 Centre Street, New York 13, N. Y.  
**Impact of Atomic Energy Industry on Community Health; Panel Discussion.** *AMA Archives of Industrial Health*, Vol. 13, 1956, pp. 425-467.  
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**Safeguard Features of a Fast-Breeder-Reactor Power Plant.** W. J. McCarthy, Jr. and F. C. McMath. *ASME Transactions*, Vol. 79, 1957, pp. 41-46.  
**Radiation Tolerance Control.** A. Graves. *Atomics*, Vol. 6, 1955, pp. 278-281.

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**Nuclear Fusion—Energy of the Future.** John Gustavson. *Jet Propulsion*, Vol. 27, May, 1957, pp. 570, 572, 574.  
**Controlled Thermonuclear Reactions Progress toward Fusion Power.** D. J. Hughes. *Chemical Engineering Progress*, Vol. 52, September, 1956, pp. 134, 136.  
**Thermonuclear Power Plants.** Hsue-shen Tsien. *Jet Propulsion*, Vol. 26, July, 1956, pp. 559-564.  
**Controlled Fusion Research; Application of Physics of High-Temperature Plasmas.** R. F. Post. *Reviews of Modern Physics*, Vol. 28, 1956, pp. 338-362.

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**Atomic Scientists' Journal.**  
**International Journal of Applied Radiation and Isotopes.**  
**Journal of British Nuclear Energy Conference.**  
**Nuclear Instruments.**  
**Nuclear Power.**  
**Nuclear Science and Engineering.**



**Registration table** did a brisk business. Despite the "austerity" forced on some West Coast aircraft companies due to the prospect of lessened military orders, registration totaled 2500 for the week.

**SOME** 2500 engineers gathered to swap ideas at the SAE National Aeronautic Meeting held in Los Angeles September 31-October 5 at the Ambassador Hotel.

For five days they attended Production Forum panels, presentation of 48 papers, four luncheons, scores of committee meetings, and innumerable technical gab fests. They not only talked and listened—they hefted sample parts, pushed the buttons of powered displays, and examined cutaways in the

hundred booths at the Engineering Display. On the sixth day, the men were joined by their ladies at the dinner-dance that capped the Meeting.

Participants in this year's Production Forum were more enthusiastic than ever. They applauded the Forum Executive Committee's decision to keep panels to more specific topics for their discussions. Those who attended the panels generally felt that the better defined subjects—plus the "austerity" enforced on the aircraft business by reductions in military spending—had cut their numbers somewhat. But every man who came was really concerned with the problems being discussed. Consensus was that the smaller audiences of more deeply interested people made for even more worth-while panels.

Some production men compared

notes with panel members and audiences just for the satisfaction of "talking shop" with fellow specialists who understood the highly technical lingo. But a management-minded group of pool-side philosophers reflected that: What's a problem to one manufacturer is usually a problem to all. Yet one plant may be a little further advanced toward the solution of one problem while another plant leads the way out of another difficulty. By trading solutions and data, everyone gains a little. And the biggest customer, the government, benefits a lot.

The best aircraft and missiles will come from a combination of competition and cooperation. Our economic system insures the competition, and SAE furnishes a medium for the cooperation, as one man put it.

The Production Forum showed



**Success of the Production Forum** was due in large part to careful planning and hard work of all the Executive Committee members, among them A. W. Morgan (left), J. A. Logan, B. K. Bucey, C. S. Wagner, J. A. Van Hamersveld, N. H. Shappell, and W. G. Dollmeyer. Others on the Executive Committee, although not in sight when the picture was taken, were C. E. Barnes, R. L. Clark, C. S. Glasgow, and W. F. Snelling. J. H. Kindelberger was chairman of the display. M. K. Carter was reception chairman. G. T. Wilson was publicity chairman.



**Panel leaders** I. Dagan (left), B. W. Clemens, J. B. Bierbower, and B. P. Gibbons were four of the 16 who presided over all-day discussions of topics of current concern to production men. The 12 panel leaders not shown were F. W. Neale, A. P. Higgins, D. F. Hays, L. K. Pratt, J. N. Willits, R. A. Phillips, A. Auerbach, Lee Stockford, J. D. Canary, B. Gaiennie, M. L. Schuehle, and F. T. Wood, Jr. Altogether 124 experts served on the 16 panels, exchanging information with their fellow panel members and the audience.

# Engineers Meet in Los Angeles

that the computer has become as much the tool of the production engineer as of the design engineer. Electronic data processing equipment is taking over more and more of the work of scheduling, shop loading, performance reporting, and parts control. EDP equipment is costly to rent, but it gives a more up-to-date picture of a complicated manufacturing situation than hand methods could possibly give.

Computers are actually controlling tools, too. In fact, it's possible to feed the designer's mathematically expressed requirements for a part's shape into the computer, and apply the computer's answer directly to the production tools that will shape the part. No drawing is needed.

This type of machine information on tapes or cards can be mailed from prime to vendor, just

as information in words or drawings is, or it can be teletyped. Thirteen contractors and eight defense agencies now talk to each other in machine language. The day may soon come when the machine language will be transmitted via microwave equipment. It was reported that one company had a data transmission method under development that would transmit 3000 bits per sec with an error rate of less than one in 10 billion.

Other opinions expressed at the Production Forum included:

- By 1959 there will be large-scale replacement of tracer-controlled profiling machinery by nu-

merically controlled tools. The new or retrofitted machinery will make possible achievement of tighter tolerances than are otherwise possible.

- Requirements for aerodynamic smoothness are tightening faster than the techniques for producing it. Compromises must be accepted to obtain sufficient production, at acceptable cost. Shop men should keep aerodynamicists informed of the limitations of production equipment. And aerodynamicists will get more sympathetic reception for their demands if they explain to manufacturing and inspection men how surface irregu-



**Advice on next year's Meeting** is sought from Harrison Holzapfel (left) and F. Herbert Sharp by Philip M. Klauber. Holzapfel was general chairman of this year's event, Sharp of last year's, and Klauber has been named to head next year's. Plans for each Meeting are begun a whole year in advance, while triumphs and errors of the previous Meeting are fresh in planners' minds.



**Practicing presentation of plaques** are W. Paul Eddy (left), Harrison Holzapfel, Walter G. Dollmeyer, and Boyd K. Bucey. SAE President Eddy presented the plaques as expressions of the Society's appreciation of the work the three men had done in arranging the Meeting. Holzapfel served as general chairman of the Meeting, Dollmeyer as sponsor of the Production Forum, and Bucey as general chairman of the Forum.



## SAE Aero Engineers Meet in Los Angeles

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larities spoil performance. Numerically controlled tools are the best hope for improved smoothness of machined surfaces.

- Modern production equipment is so complex that it pays to assign an engineer to trouble-shoot, along with skilled maintenance men. Out of his knowledge of electronics, metallurgy, and machine design, the engineer can often save hours of valuable machine time in locating a faulty element.

- Reliability of systems and components is vital to the missile. Therefore, equipment to test the components as the missile comes off the line and at various opportunities until its firing assumes new importance. There's need to

consider the test equipment from the inception of a weapon system and to work on it right along with the vehicle. Trend is toward more fully automatic test equipment to speed preparation for take-off or launch.

- Bonded sandwich and bonded metal-to-metal structure have not necessarily been outmoded by increases in operational temperature requirements. Inorganic and ceramic adhesives, if they can be developed soon enough, will be adequate for bonding. These new adhesives might make bonded structure competitive with brazed structure.

- Cooled ceramic tools aren't yet up to carbide tools, but they would be an acceptable substitute on many jobs if a time comes when there aren't enough carbide tools to go around.

- Metal removal experts want more information on how to cool work piece and tool with liquid carbon dioxide, and how fast they can cut with such refrigeration.

Each Production Forum panel included a panel secretary whose duty it is to prepare a report detailing the information exchanged by his group and its audience. These reports will be collected and published about two months after the Forum as SAE Special Publication SP-321 at \$3 to members and \$6 to nonmembers. The reports will also appear in abridged form in SAE Journal.

Engineers concerned with design and operation of aircraft and missiles presented 48 technical papers in 16 sessions of more-or-less conventional format, and dramatized the problems of transitioning an engineer from technical to supervisory work in one theater-in-the-round session. All but one of the papers were available at the Meeting in preprint form and will continue to be available at 50¢ to members and 75¢ to nonmembers for a year. All 47 will be noted in the "Briefs of SAE Papers" column appearing in SAE Journal, and many will receive lengthier treatment as well.

The papers covered the whole spectrum of air vehicles from rocket-propelled missiles to commercial airliners, and even small reconnaissance craft. Just as production engineers spent much of their time explaining how they were using computers, so did design and operation men. In fact, the day after 75 production men spent five hours or more discussing how electronic data processing equipment helped them keep their shops busy but not overloaded, a design engineer for a transport builder described how he worked the process backward. He analyzed airline route structures to determine the characteristics of the most efficient airplane to serve them.

An engine designer revealed what some in his audience considered to be one of the secrets of the success of Pratt & Whitney aircraft turbine engines: a surge-line survey of 500 hypothetical compressors. The survey was carried out about five years ago on a card programmed calculator. Its results have since been applied in designing compressors that will perform satisfactorily over a wide range of operating conditions.

Engineering talent expressed the highly complex interrelationships of many variables on the perform-

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**Manly Memorial Awards** were presented to Harold B. Finger (left), and William A. Benser, both of NACA's Lewis Flight Propulsion Lab, by Kenneth Campbell, chairman of the Manly Board of Award. Finger and Benser received the award for their paper on compressor stall phenomena, which the Board judged the best paper presented before the Society in 1956 in the field of aircraft powerplants. Serving on the Board with Campbell were Raymond W. Young and Allan Chilton.



**SAE's role in missile engineering** was the topic of conversation among a group Frank W. Fink, adviser to the SAE president on missiles, brought together. Included were (at Fink's left in left photograph) Harold W. Zipp, A. T. Carah, Harry C. Nissen, and SAE President W. Paul Eddy. Along the other side of the table (right photograph) were Arthur L. Klein, Dr. Clayton R. Lewis, William C. Heath, SAE Secretary John A. C. Warner, and Joseph Famme, seen seated with Fink at the right. Group agreed that everyone in the aircraft business is interested in missiles, and many SAE members are working on them. Consensus was that the Society should certainly serve its members with information on the subject, particularly on such topics as reliability of components, systems design, ground support equipment, and production methods.

**Shock and Vibration Symposium** participants, some of whom are shown here, gathered for a get-better-acquainted dinner the evening before their all-day program. Host was Dr. C. T. Molloy of Lockheed (second from right) chairman of SAE Committee S-12, which sponsored the symposium.



**Working hard and enjoying it** while SAE Committee S-1 discusses aeronautic drafting practices are L. E. Reichenbaugh (left in left photograph), M. J. Church, L. M. Holzappel, and T. C. Pritchard. At end of table sit Committee Secretary L. E. Trefny, Chairman Wayne Stone, and J. M. Steeves. Out of the camera's range were W. B. Billingham, H. M. Favor, W. B. Frisbie, G. M. Garcina, J. A. Kabrud, H. C. Mudgett, Joseph Stannard, and C. G. Taylor. Committee S-1 was one of several technical committees which met during the SAE National Aeronautic Meeting.



## SAE Aero Engineers Meet in Los Angeles

Engineers attending the Meeting enjoyed comparing opinions of three of the luncheon speakers who happened to touch on some of the same topics. Here are the speakers' comments on:



**Lt.-Gen. C. S. Irvine** (right), USAF deputy chief of staff for materiel, with **J. L. Atwood** of North American Aviation, who introduced Irvine to his Tuesday luncheon audience.

### Irvine said:

Supersonic Aircraft	<p>I expect to see manned flight at 15,000 mph at 500,000 ft. We are programming for a high supersonic long-range interceptor. And we are designing a supersonic bomber, a chemical bomber, the WS-110, as a follow-on for the B-52.</p>
Piloted Aircraft versus Missiles	<p>Manned bombers and fighter-interceptors will be vital to national defense for a long time to come. In fact, in light of the state of the art of guidance systems now known to us, it is probable that these types of manned aircraft will never be entirely replaced.</p>
Economics	<p>Quickest way to bankrupt the country would be to spend so much on defensive equipment in the vain hope of keeping every single enemy bomber out that we could not afford the strong offensive striking force that will deter the enemy.</p>
Trends	<p>The decisive phase of any future major war will be short. The strugglers who lose the first decisive onslaught will be largely disorganized and dispersed, unable in the final analysis to overcome their first losses and become effective as a military force.</p> <p>If an all-out war starts, the United States will win or lose the decisive phase with what it has on hand at the outbreak of hostilities.</p> <p>Besides maintaining the ability to deter a full-scale war, we must maintain enough flexibility and versatility in the Air Force to cope with small-scale wars.</p>



**Air Commodore F. Rodwell Banks** (left) of the Bristol Aeroplane Co. with **J. B. Wassall** of Lockheed, speaker and toastmaster, respectively, at the Wednesday luncheon.



**B. F. Coggan** (right) of Convair with Toastmaster **F. H. Rohr** of Rohr Aircraft, who presided over the Monday luncheon, first of four held in the Cocoanut Grove.

### **Banks said:**

Next big step in civil aviation will be the long-range supersonic airliner, but I doubt if such an animal can be in service much before 1975. I cannot convince myself that the economics of supersonic flight are practical for any range or stage length less than 3000 miles. But a greater range may be far more difficult to achieve.

By supersonic, I mean in the region of Mach 1.7-2, say cruising at 1.6. Because of the enormous increase in cost, a smaller step, say from Mach 0.86 to 1.3, would hardly appear to be justified. Any speed beyond Mach 2 would multiply cost and complexity many times.

I am in full agreement with your present outlook that active development of the manned military aircraft must be continued during the evolution of the missile. We can foresee no new extreme-performance interceptors or manned fighters after 10 or 15 years, and we foresee the end of the manned bomber in about 20 years.

I would now estimate that development of a supersonic transport for 1975 would cost £100,000,000 (\$280,000,000) for two prototypes and the necessary jiggling and tooling for production.

With military aviation taking to missiles, as it is in Britain, civil aviation will have to bear both the risks of introducing its planes into service and the costs. This will tend to slow the rate of development.

Within the next 50 years, there might be a marked shortage of natural fuel, both solid and liquid, if the various demands for public utility power and surface and air transportation increase at the current rates. Nuclear energy will certainly alleviate the problem in so far as public utility and shipping problems are concerned.

Governments may eventually be forced to impose restrictions leading to a stocktaking and high-pressure development along other paths.

### **Coggan said:**

I believe that in some 20 years the flagships of the world airlines will be supersonic. We will, I am sure, be able to fly around the world in one day.

In less than 10 years, we undoubtedly will see an atomic-powered plane capable of unlimited range, high altitude, and supersonic speed. Nevertheless I believe chemical fuels will dominate the field for at least another 25 years.

It is quite unlikely that passenger-carrying rockets will speed from New York to London in the foreseeable future. The fuel capacities required would be too high. Besides, such flight would probably require "tying down" the passenger. Why would anyone wish to fly uncomfortably from New York to London in 20 minutes if he could make it comfortably in 2 hours?

Supersonic transports may well cost over \$10,000,000 each. In the past, airline equipment was paid for out of reinvested earnings, cash accumulations from fast depreciation and tax amortization certificates, equity financing, and short-term bank credits. Only infrequently were these methods supplemented by long-term debts, and then the maximum term was usually 20 years. Now airlines must borrow long before the planes will be flying because we manufacturers must have progress payments to help finance these more expensive airplanes.

There's increased need for engineers to be cost conscious all the way. As an example of what engineers can do to help, let me cite the in-flight system check plan that Convair maintenance engineers have been working on to cut costly maintenance delays on the ground. The idea is to determine replacement components needed and have them at the ramp when the plane lands. You'll see more and more of this type of maintenance thinking—and production and inspection thinking, too—getting into the picture at the start of design instead of later.



**SAE SAN DIEGO SECTION** members led by Robert G. Sharp of Ryan developed a novel Friday afternoon session for the Meeting on the subject of engineering supervision.

People who showed up for the session found their chairs arranged in a hollow square around a conference table set on a low stage. At 2 p.m. a group of engineer-actors mounted to the table and began an engineering staff conference of the Hit Missile Co. Problem under discussion was selection of a new supervisor for the Company's fuel system group.

The conferees—each taking in the hypothetical company a role similar to his real-life role—agreed that whoever was selected for the job should have such qualities as ability to communicate ideas, receptivity to information, an ulcer-free-disposition, business sense, and integrity. Then they interviewed two "candidates" for the job.

At this point, the audience took a coffee break and clustered around "buzz" leaders to ponder the choice.

When the conferees reassembled on their stage, they announced their choice of candidate. Then written comments—including choices and reasons for choices—of the buzz groups were read aloud for comparison.

Before the actors concluded their appearance they replied to the comments of the buzz groups.





## SAE Aero Engineers Meet in Los Angeles

continued from page 86

ance of compressors. Digital computers performed the tedious calculations.

Computers are speeding up flight test programs. They rapidly analyze data from the last flight to assure that all systems worked satisfactorily and that no potentially dangerous differences from design performance developed. Only with that assurance is it safe to expand the flight envelope.

A system has been designed for the YP6M-1 Seamaster to convert flight test data to digital form in the airplane before it is recorded on magnetic tape, it was reported. At the end of the flight the tape is ready for use at the data reduction center.

Digital computers shared the glory with analog computers. The later type computers were particularly the pets of the systems engineering people for study of non-linear systems.

In the systems approach to design, it was explained, desired performance of each individual component is determined by studying its effect on the performance of the whole system. Components are simulated rather than actually built, except where existing pieces must be incorporated.

First step in simulation is to formulate the system's behavior as a series of mathematical expressions. Then the analog is created by forming another handler-to-manipulate system—usually electronic—satisfying these equations.

The Firebee target drone's flight control system was cited as a product of the systems approach. Not only was the analog used to determine required component performance—but as components were roughed out, they were substituted into the analog. Their inclusion developed valuable clues on reliability and trouble-shooting and even served to train future operators.

Close cousin to the computer is the automatic maintenance equipment being considered for some military and commercial air vehicles. One projected type, termed

rapid automatic checkout equipment or RACE, tells:

1. Name and identification number of a faulty unit.
2. Length of down time.
3. Location of spare unit.
4. Type of technician required to make repairs.
5. System power and arming conditions under which the repair should be made.

Next step is checkout equipment to check out the checkout equipment. While it was agreed that airline operators wouldn't want to go this far, it was readily conceded that judiciously applied automatic maintenance equipment could save them great sums on their big, fast, new turbine transports. The devices need not be so complicated as the military versions but should show whether or not the system is working properly; if not, which component is faulty; and whether the tolerances are such that the system is about to fail.

To which system is application of automatic maintenance equipment economically justified? "Let the computers weigh the cost factors and give us the answer" was the consensus.

When engineers at the Meeting weren't discussing computers and other tools of their trade, they were often engaged in discussing the new organizational form for the Society which is being worked out by the Planning for Progress Committee. Discussion of the plan in several committee meetings brought out that it provides for what is being called, at least tentatively, a Professional Engineering Board to oversee technical services to members. The Board is patterned after the present SAE Technical Board, which oversees technical services to industry, such as standardization work.

Under the Professional Engineering Board would come the successors to the present Activity Committees. Each of these new committees would be responsible for keeping alert to developments in its field, securing information on them, and getting it to members via meetings and publications.

This concept of future Activity Committee operations appealed to the present aeronautic Activity Committees enough so that each decided to try it out.



Clarence M. Belinn (left), speaker at one of the luncheons apparently had a good story for Robert Wagner of Hiller Helicopter, who introduced Belinn.

**B**ELINN, who is president of Los Angeles Airways, Inc., foresaw a multi-engine helicopter of 16,000-lb weight and a capacity of 24 passengers plus property. Speaking at the Thursday luncheon, he expressed the hope that this new machine would offer:

- All-weather flying.
- Greater mechanical dependability.
- Lower ton-mile and seat-mile costs.
- Improved passenger acceptance.
- Increased safety.

The helicopter of the future—plus the long-range jet transport—will make it possible for a passenger from Los Angeles to fly to New York and back all in the same day. A passenger leaving San Bernardino at 5:50 a.m., for example, could hop to Los Angeles Airport, arriving at 6:30 a.m. Leaving the airport at 7:00 a.m. he would arrive at a New York airport at 8:00 p.m. By 2:30 p.m. he could be at his destination in Manhattan.

Using the helicopter and jet transport to return, he could leave Manhattan at 7:00 p.m. and—taking advantage of the difference in time zones—arrive at San Bernardino at 9:34 p.m.

## Dr. Hafstad . . .

. . . appointed chairman of new Science-Engineering Advisory Committee.

TO reduce the gap which exists between scientific discovery and practical automotive engineering, the SAE



Dr. L. R. Hafstad

Council has created a new presidential advisory committee on science and engineering. Dr. L. R. Hafstad, vice-president, Research, General Motors

Corp., has been appointed chairman of the group.

One of the Science-Engineering Advisory Committee's primary aims will be to expose Society members and industry to the ideas and scientific disclosures emanating from research laboratories. The committee will guide SAE activities toward this goal, since developments in solid-state physics, nuclear chemistry, and electronics are having such far-reaching effects on the automotive and aeronautical engineer. Never before has industry had to meet such stringent performance requirements for all types of equipment and machinery.

At an informal discussion last spring, Dr. Hafstad pointed out that in the past, there has often been a gap of up to a hundred years between the discovery of scientific fact and practical engineering application. Today, the gap is a constantly diminishing one. However, to keep pace with technology, definite measures must be taken to reduce the gap even more.

More recently, Dr. Hafstad spoke of the "push-pull" relationship which exists between science and engineering. Science or engineering advance only

when the other has made conditions ripe for advance.

Dr. Hafstad also observed, "Engineering is the exploitation of science, and to be successful, it must be given some science to exploit."

Announcement of committee membership will be made at the next Council meeting to be held in Detroit in January.

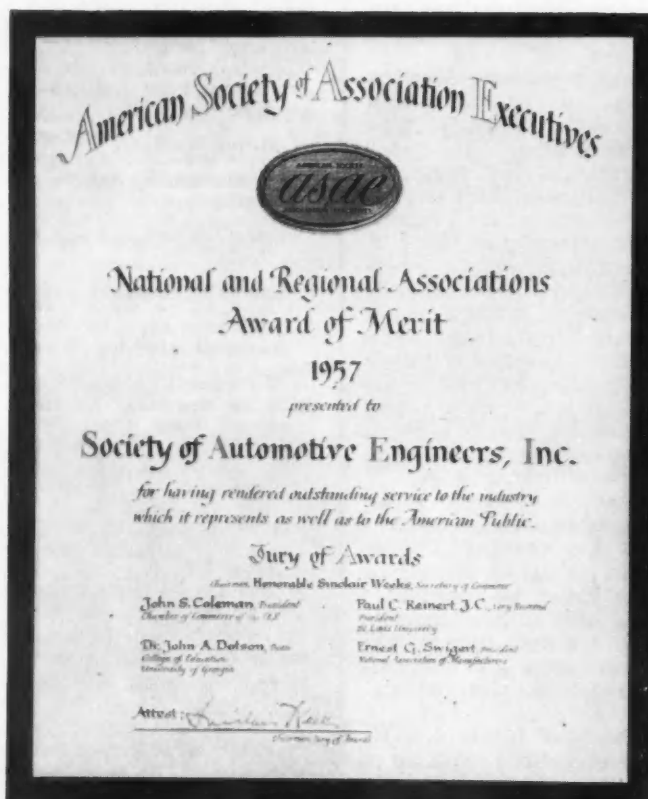
## You'll . . .

. . . be interested to know . . .

SAE PAST-PRESIDENT A. W. HERRINGTON has been elected president of the Automotive Old Timers. At the 18th AOT Anniversary Dinner, October 8, SAE members receiving distinguished service citations were THOMAS W. MILTON and ROBERT E. WILSON.

M. R. BENNETT, Construction Equipment Division, International Harvester Co., represented President Eddy at the presentation of the Sperry Award on October 10 to Harold L. Hamilton, Richard M. Dilworth, and Eugene W. Kettering. The Award was

## CEP Gets National Award



THE Society's Cooperative Engineering Program recently received an Award of Merit from the American Society of Association Executives. This recognition was given to the work of the SAE Technical Board and its committees in a competition among trade and professional associations for service to their respective industries.

The award was presented to the Society at the ASAE Annual Meeting in St. Louis on September 19 in the form of a plaque, a copy of which is shown at left. The citation accompanying the award read in part: "To the Society of Automotive Engineers . . . for its long service as the Engineering Partner of the Automotive and Aeronautical Industries."

SAE President W. Paul Eddy, in announcing the award to Council at its meeting in Milwaukee, paid tribute to the thousands of men serving on hundreds of SAE technical committees, and to the leadership of the Technical Board. The harmonious, constructive working together of leading engineers on those industry problems which lend themselves to cooperative solution is what made this possible, he said. Industry also recognizes the value of this work by the support given by top management to the men serving on the committees and by the financial support of the Cooperative Engineering Program itself.

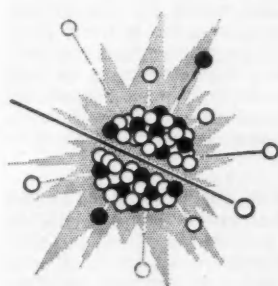
made in Chicago during the 1957 Fall Meeting of the American Institute of Electrical Engineers. (For a story about the Award winners, see page 102 of the October Journal.)

**AN ANALYSIS** of figures supplied in budget reports by SAE Sections and Groups for the year 1956-57 indicates a total of about 400 meetings held with an overall attendance approximately 35,000.

**SAE IS CO-SPONSORING** four aeronautic sessions on December 2 and 3 at the Annual Meeting of the American Society of Mechanical Engineers at the Hotel Statler, New York. Theme of the sessions on which SAE is cooperating is "Operational Support for Tur-

bine-Powered and Cargo Aircraft" . . . speakers will include many distinguished aircraft men. Among those scheduled are: M. Whitlock, American Airlines Inc.; Col. S. P. Triffy, USAF; P. N. Borsky, University of Chicago; R. Boyd Ferris, ITA; R. Tolson, Texas Co.; Paul L. Smith, Douglas Aircraft Co.; R. Dixon Speas, aviation consultant; R. Norden, Seaboard & Western Air Lines; Dr. H. O. Parrack, USAF; L. R. Hackney, Air Logistics Corp.; and E. O. Cocke, Trans-World-Airlines, Inc.

**GERALD E. KEINATH** has been appointed to the membership of the SAE Overseas Information Committee. Keinath serves as business manager, European operations, Battelle Institut e. V., Frankfurt, Germany.



## NUCLEAR NEWS NOTES

A report of the SAE Nuclear Energy Advisory Committee

### Radiation Research Grows In Petroleum Industry

**R**ADIATION research in the petroleum industry is in a conspicuous growth period. Implications of this trend are particularly important to automotive engineers.

The industry is rapidly investing in its own accelerators, radioactive sources, hot cells, and tracer laboratories. According to a recent survey, 11 particle accelerators are in use or planned for installation—nine Van de Graaff's, a linear accelerator, and a resonant transformer. Six  $\text{Co}^{60}$  sources are listed, ranging from 15 to 35,000 curies. Two companies are conducting reactor radiations; one group is planning to build a reactor; and three laboratories have or will have spent-fuel elements.

With this equipment, the industry is actively investigating applications of radiation and other nuclear techniques. The research projects now under way or being considered cover such investigations as:

1. Petroleum exploration and production problems. For example, one company is investigating ways to improve the interpretation of existing radioactive logging techniques by studying active thermoluminescence of carbonate rocks.

2. Ways to improve various types of refinery processes, fuel and lubricant products, and petrochemical production.

One company is exploring hydrocarbon cracking to produce high-octane gasoline, and the fabrication of new byproducts. Another company has made sample quantities of gasoline and other oil products with the aid of gamma radiation. Sample quantities of octane have been made by bombarding butane hydrocarbons with electron beams.

3. Effects of radiation on petroleum and its products. Companies are investigating what radiation does to the hydrocarbon molecules that make up petroleum, the effects of radiation on lubricants, hydraulic fluids, greases, and other materials.

4. Use of radioactive isotopes as tracers to study such problems as:

- (1) Origin of engine deposits—by labeling different fuel components with  $\text{C}^{14}$ .
- (2) How wear and corrosion occur.
- (3) Measure effects of lubricants on engine wear.
- (4) How greases and oils lubricate.
- (5) Why some jet fuels are better than others.

## SAE National Meetings 1958

January 13-17  
Annual Meeting and  
Engineering Display,  
The Sheraton-Cadillac  
and Statler Hotels,  
Detroit, Mich.

March 4-6  
Passenger Car, Body  
and Materials Meeting,  
Sheraton-Cadillac Hotel,  
Detroit, Mich.

March 31-April 2  
Production Meeting and Forum,  
The Drake, Chicago, Ill.

April 8-11  
Aeronautic Meeting,  
Aeronautic Production Forum,  
and Aircraft Engineering Display,  
Hotel Commodore, N. Y., N. Y.

June 8-13  
Summer Meeting,  
Chalfonte-Haddon Hall,  
Atlantic City, N. J.

August 11-14  
West Coast Meeting,  
Ambassador, Los Angeles, Calif.

September 8-11  
Farm, Construction  
and Industrial Machinery,  
Production Forum,  
and Engineering Display,  
Milwaukee Auditorium,  
Milwaukee, Wis.

September 29-October 3  
Aeronautic Meeting,  
Aircraft Production Forum,  
and Engineering Display,  
Ambassador, Los Angeles, Calif.

October 20-22  
Transportation Meeting,  
Lord Baltimore Hotel,  
Baltimore, Md.

October 22-24  
Diesel Engine Meeting,  
Lord Baltimore Hotel,  
Baltimore, Md.

November 5-6  
Fuels and Lubricants Meeting,  
The Mayo, Tulsa, Okla.

# About SAE Members



Lewis



Ballhaus



Dawson



Hense



Geniesse



Brown



Willis



Drew



Case



Bower

**DR. CLAYTON R. LEWIS** has been named chief engineer of the newly created basic sciences section of the Research Staff, Chrysler Corp. Formerly Lewis was chief engineer in charge of nuclear research, Engineering Division, for the company.

Lewis will be responsible for the general administration of activities concerned with basic and applied research in all branches of physics, applied research and development of research instrumentation and equipment, and chemical research studies and analyses of all automotive non-metallic materials and their applications. In addition, he will be responsible for coordinating these activities with other operations within the Research Staff and the Engineering Division.

A member of SAE since 1944, Lewis is chairman of the SAE Nuclear Energy Advisory Committee and chairman of the SAE Surface Finish Committee.

**WILLIAM F. BALLHAUS**, has been elected a vice-president of Northrop Aircraft, Inc., and has been made general manager of the company's newly-created Nortronics Division. Formerly Ballhaus was vice-president and chief engineer of the Northrop Division, Hawthorne, Calif. The new division will handle design, development, and manufacture of electronic, electro-mechanical, and opto-mechanical products and components.

**H. D. DAWSON** has retired as general manager, Delco-Remy Division, General Motors Corp. Dawson has been with the company for 32 years, starting in the Delco-Remy Division. In 1932 he became chief engineer and four years later became assistant factory manager. In 1940 Dawson was made factory manager, assistant general manager in 1947, and has been general manager since 1950.

**VERNON E. HENSE**, formerly assistant general superintendent, has been named general superintendent of Buick's Manufacturing Division, General Motors Corp. Hense joined Buick in 1930 as a student engineer, became metallurgical inspector in 1934, assistant metallurgical engineer in 1941, and took over the department in 1951 as chief metallurgical engineer.

Hense is now serving as chairman of the SAE Iron and Steel Technical Committee.

**JOHN C. GENIESSE** has been made manager of the newly-created product development and technical services, marketing department, The Atlantic Refining Co. He formerly was a divisional director in the company's research and development department.

Geniesse now serves on the SAE Fuels and Lubricants Technical Committee, and was SAE vice-president

representing Fuels and Lubricants Activity in 1946.

**B. GRATZ BROWN** has joined the engineering staff of Sterling Aluminum Products, Inc. Formerly he was chief engineer with the Dexter division of Fram Corp. Brown, an automotive development engineer, will represent Sterling in the Detroit area.

A graduate of Massachusetts Institute of Technology, Brown has served as a research engineer with General Motors Corp. in Detroit, and with AC Spark Plug Division of GMC in Flint. He also worked on the development of new automotive products with the engineering research division of Ford Motor Co.

**NEWTON H. WILLIS** has recently been named vice-president of engineering, Waukesha Motor Co. He is also general manager of the Railway Division, and will continue in this capacity. Willis started with Waukesha in 1930 as a design and engineering draftsman; in 1933 joined the Railway Division, and was named its general manager in 1953.

**PHILLIP W. DREW** has been named manager-engineering, automobile tires, Goodyear Tire & Rubber Co. Drew, manager of Captive-Air Safety tire development prior to his new appointment, continues to be responsible for this activity, as well as other types of passenger tire design.

**C. ROBERT CASE**, formerly manager, engineering truck tire development, Goodyear Tire & Rubber Co., has been appointed to the newly-created position of development manager—tires, Goodyear International plants.

**LLOYD L. BOWER**, chief engineer of the Waukesha Motor Co., has retired from the company. Bower joined Waukesha in 1927 and has served as chief engineer since 1949.

**J. R. MERRIAM**, formerly assistant chief engineer, Waukesha Motor Co., has been named chief engineer replacing Bower. Merriam has been with the company since 1920.

**A. W. POPE**, chief research engineer, Waukesha Motor Co., will continue in this capacity, and in addition will direct development work on new type diesel engines and gas turbine free-piston engines.

Pope is now serving on the SAE Council, and is a past-vice-president representing Diesel Engine Activity.

**E. R. RUTENBER**, formerly chief installation engineer, and **H. M. WILES**, formerly assistant chief research engineer, have been named to the posts of assistant chief engineers, Waukesha Motor Co.

**J. P. KELLY** has been made chief design engineer for the Waukesha organization, having served previously as chief draftsman.

**H. C. BEYER** has recently formed his own organization, H. C. Beyer Associates Inc., "which combines people banded together to integrate their experience and knowledge as a service to the engine and power generation field at large." Beyer is serving as the president.

Formerly Beyer served as executive vice-president and general manager, International Ferment Machinery Co., Inc., and also has been general manager of Atlantic Diesel Mfg., Inc.

**EDWARD F. OBERT**, professor of mechanical engineering, Technological Institute, Northwestern University, has left for Alaska to study problems of environmental control in the Arctic. Serving as a consultant to the commander of the Arctic Aeromedical Laboratory, his association is with the U.S. Air Force at Ladd Air Force Base.

**CHRISTOPHER C. RACHAL, JR.** has joined Trans World Airlines as structures engineer. Prior to his new post, Rachal was with Temco Aircraft Corp. as structures engineer.

**IGOR I. SIKORSKY**, retired engineering manager, Sikorsky Aircraft Division, United Aircraft Corp., has been awarded the National Business Aircraft Association's Annual Meritorious Award. The plaque presented to Sikorsky reads: "To Igor I. Sikorsky whose half-century of vision, resourcefulness and determination in pioneering and developing fixed and rotary wing aircraft has given new dimensions to the world community of commerce."

**FANNING M. BAUMGARDNER**, chief, winterization section, Department of the Army, Research and Development Laboratories, has been awarded a Secretary of the Army Research and Study Fellowship. The award gives career employees a year's leave of absence from their jobs for research and study in their particular field. Baumgardner will concentrate on means of producing electrical energy from fuels.

Baumgardner serves, as one of the most active members, on the Winterization Subcommittee of the SAE Construction and Industrial Machinery Technical Committee.

**ROBERT R. FURNEY** has been named assistant chief engineer, Clutch Division, Dana Corp. He joined the division in 1952 and has been serving as clutch engineer.

**MYRON M. SCHALL** has been named assistant chief engineer, Hydraulic Transmission Division, Dana Corp. Schall has served with Dana for 20 years as an engineering draftsman and hydraulic transmission engineer.

**ROBERT E. FLETCHER**, mechanical transmission engineer, Mechanical Transmission Division, Dana Corp., has been named assistant chief engineer of

## AUTOCAR DIVISION CHANGES

**SAE PAST-PRESIDENT B. B. BACHMAN**, whose career has almost spanned the automotive age, is going into semi-retirement at The Autocar Division, in Exton, Pa., of The White Motor Co.

Bachman, who joined The Autocar Co. as a draftsman in 1905, when the automobile was still a new-fangled contraption, will continue, however, as director of engineering on a part-time basis. Bachman continues to be SAE Treasurer, a post to which he was first elected in 1944.

Part of his duties will be taken over by **ERNEST R. STERNBERG** who has been appointed administrative engineer.

Autocar also announced the appointment of **LAURENCE COOPER** as chief engineer; **MAURICE A. HUTELMYER**, chief chassis engineer; and **G. RALPH STROHL**, director of research.

Ernest R. Sternberg, who as administrative engineer, takes over part of Bachman's duties, has been project engineer for Autocar. Previously, he was assistant to the vice-president in charge of production at the Cleveland plant, and general manager of the Sterling Division of The White Motor Co.

Laurence Cooper, Autocar's new chief engineer, formerly was staff engineer. With the company for almost 30 years,



he has been a junior draftsman, supervisor of special car engineering, and chassis engineer.

Maurice A. Hutelmyer, the new chief chassis engineer, has been with Autocar for 23 years as a checker, draftsman, supervisor of the special car group, and recently, as chassis engineer. He is currently chairman of SAE's Philadelphia Section.

G. Ralph Strohl, who has more than 35 years service with Autocar, was staff engineer before his appointment as director of research. Previously, he was experimental engineer and assistant chief engineer.



Sternberg



Cooper



Hutelmyer



Strohl

the division, in charge of production engineering activities. Fletcher has been with the company for eight years.

**CARL J. GUSTAFSSON** has been made assistant chief engineer, Mechanical Transmission Division, Dana Corp., in charge of advanced engineering activities. Gustafsson has been with Dana since 1948.

**DONALD E. HARPFER**, formerly assistant manager of industrial products, research and development, Industrial Products Division, Goodyear Tire & Rubber Co., has been made manager of industrial products technical liaison.

**JOHN H. GERSTENMAIER** has been made manager of industrial products

development, research and development, Industrial Products Division, Goodyear Tire & Rubber Co. Formerly he was manager of development for the company's St. Mary's, Ohio plant.

**T. A. HALLER**, formerly director of engineering, Industrial Division, J. I. Case Co., has been made head of the newly-created research and development center of the company. Haller has also served as vice-president in charge of engineering of American Tractor Corp., before the company merged with Case. In his new post, he will have overall supervision of engineering for both Agricultural and Industrial Divisions.

Rockwell



**WALTER F. ROCKWELL** has been elected to the board of directors, Hercules Motors Corp. He also serves as chairman of the Finance Committee, Rockwell Mfg. Co., and director, Rockwell Spring & Axle Co.

Rockwell is a member of the SAE Finance Committee, and in January, 1958, begins a five-year term as a member of the SAE Publication Committee.

**CHARLES BALOUGH** has retired as chairman of the board and a director, Hercules Motors Co. One of the founders of the company, Balough has been chairman of the board and a director since retirement as president four years ago.



Keplinger

**JOHN C. KEPLINGER** has retired as president of Hercules Motors Corp., and will remain as a director and executive consultant to the company. Keplinger has been with Hercules since 1926.

## AT NEW DEPARTURE DIVISION

of GMC . . .



Stoner

Rhame

**SETH H. STONER** has been made general manager of the New Departure Division, General Motors Corp. Formerly he was chief engineer of the New Departure Division.

**PAUL W. RHAME**, a veteran of 34 years with General Motors Corp., has retired as general manager of New Departure Division.

(This item last month was incorrectly positioned under a headline "Ford Motor Co. Changes . . ." New Departure is, of course, a division of General Motors Corp.)

**VICTOR G. RAVIOLO**, special assistant to the vice-president, engineering and research, Ford Engineering Staff, Ford Motor Co., recently addressed the American Association of Motor Vehicles Administrators' Conference in Roanoke, Va. Raviolo proposed a threefold approach to safer transportation through more widespread use of seat belts and other safety equipment, improved roads and uniform traffic regulations, and continued progress in the design of motor vehicles controls.

**CARL F. SCHORY** has retired as service manager, Hamilton Standard Division, United Aircraft Corp., and been appointed assistant to the general manager. He had served as service manager for 27 years. In his new position, Schory will travel extensively throughout the country for the company.

**DANIEL W. KAPLAN** has been named junior test engineer at Mack Trucks, Inc., Allentown, Pa. Prior to his new position, Kaplan was in the U. S. Army.

**JOHN S. GABEL** has been made methods and standards engineer with E. I. DuPont de Nemours and Co., Inc. Previously he had served as shift supervisor, reactor department, for the company.

**CARL A. SCHWANBECK** has been named senior nuclear engineer, Nuclear Division, Lockheed Aircraft Corp. Formerly he was an engineer with the Atomic Power Division, Westinghouse Electric Corp.



Garbarino

Valentine

**FREDERICK J. GARBARINO**, formerly director of quality control, New Departure Division, General Motors Corp., has assumed a newly-created position as the division's director of sales and engineering.

**RICHARD H. VALENTINE** has been made chief engineer, New Departure Division, GMC. He joined New Departure in 1939, and has been engaged in ball bearing sales engineering assignments in the Detroit and Cleveland areas for many years. For the past two years he has been assistant chief engineer.

**GILBERT K. HAUSE** has been named engineer in charge of the transmission development group, Engineering Staff, General Motors Corp. He succeeds **OLIVER K. KELLEY**, who has gone to Buick as chief engineer. Hause has been executive assistant engineer of the transmission group.

**GEORGE R. SMITH**, formerly assistant engineer in charge of the transmission development group, Engineering Staff, GMC, takes Hause's place as executive assistant engineer. Smith joined the Detroit Transmission Division in 1939 and in 1940 was transferred to the transmission development group.

**CLIFFORD C. WRIGLEY** has become assistant engineer in charge of the transmission development group, Engineering Staff, GMC. Formerly Wrigley served as project engineer of the same group, having joined them in 1942.

**ERNEST L. SIMPSON** has joined Elcombe Engineering, Ltd., as engineer. Formerly he served as Vehicle Development Division engineer with the Department of National Defense (Army), Ottawa, Ont., Can.

Simpson has served as past-regional vice-chairman of Windsor and Ottawa, SAE Montreal Section.

**LT.-COL. SIDNEY G. HARRIS**, USAF, is now chief, Petroleum Branch, Headquarters, Eighth Air Force, Strategic Air Command, Westover AFB, Mass. He was formerly director of fuels and lubricants, Far East Air Logistic Force, Japan.

Harris has been a member of SAE since 1924, and served as chairman of the SAE Metropolitan Section in 1935.

**BRUCE W. WADMAN**, managing editor of "Diesel Progress," is now in charge of the publication's newly-opened midwestern headquarters in Milwaukee, Wis.

**EUGENE W. JACOBSON** has been named to represent the American Society of Mechanical Engineers on the board of directors of the American Rocket Society. Jacobson is chief design engineer in charge of the design section, Executive Branch, Gulf Research and Development Co.

**JOHN SASSO**, vice-president and a director, G. M. Basford Co., has been made a senior vice-president of the company.

**DONALD F. KEHN** has been made account manager for the Allison Division, General Motors Corp., at the Kudner Agency, Inc. Formerly he served with the agency as technical writer.

**JOHN A. NEWTON** has joined Lubrizol Corp. as staff engineer. Previously he was factory manager of Thompson Products' valve division.

**CLARE L. HITCHCOCK** has joined Diamond T Motor Car Co. as director of market research. Formerly he was with Studebaker-Packard Corp. as truck sales manager.

**T. J. WILKINSON** has been named assistant supervisor of the passenger car and accessory section in the Technical Service Division, Ethyl Corp. Formerly he served as automotive engineer, technical service, for the company.

**H. M. SMITH**, formerly research chemist, Esso Research & Engineering Co., Product Division, has been appointed engineer in the engineering services section of the Technical Service Division, Ethyl Corp.

**G. E. SAXON** has been appointed to the newly created position of technical assistant to the director of Technical Service Division at the Ethyl Corp. Formerly he was research engineer, Technical Service Division.

**GERALD E. BRIGGS** has been made district sales manager at the Reo Division, White Motor Co., Cincinnati, Ohio. Formerly Briggs was branch manager at Reo Motors, Inc., before it became a division of White Motor Co.

**MYRON DUNN** has been made a propulsion engineer at The Martin Co., Denver, Colo. Formerly Dunn was a research engineer at Chrysler Corp., Engineering Division.

**JAMES H. TARTER**, formerly graduate student at Purdue University, is now junior engineer at the Bendix Aviation Corp., Hamilton, Ohio.

**EUGENE S. KROFT** has been made assistant to the regional administrator, Civil Aeronautics Administration, Los Angeles. Formerly he was assistant to the dean, Parks College of Saint Louis University.

Kroft has served with the SAE St. Louis Section as secretary in 1955-56, and Vice-Chairman of Student Activities from 1950-52.

**JAMES ROBERT MONDT** has re-joined the Research Staff, General Motors Corp., as junior research engineer in the gas turbine department. Mondt is returning to a new position with GMC after completing work for a Master of Science degree in Mechanical Engineering at Stanford University on a General Motors Fellowship.

**CHARLES S. WHITE** has been made manager of Micromatic Hone Corp.'s Research Division in Palmdale, Calif. Formerly White served as a consultant for American Metal Products Co., and will remain with American Metal Products in this capacity.

**HARRY A. WILLIAMS** has been named managing director of the Automobile Manufacturers Association. He joined AMA in 1942 as editor of "Auto-

mobile Facts," was made director of information in 1949, and has served as public relations director since 1952.

**CHARLES E. PETERSON** has been made manager of manufacturing operations, Mackintosh-Hemphill Division, E. W. Bliss Co. Previously he served as chief metallurgist, a position he held since 1954.

**CLAYTON J. PAJOT** has become a professor of engineering mechanics at the University of Detroit. Prior to his new position, Pajot was chief stress engineer, Nash Research Division, American Motors Corp.

**T. HAROLD LINDHOLM** has been made division automotive engineer at the Shell Oil Co. in Los Angeles. Prior to this post, Lindholm was automotive engineer with the Detroit branch of the company.

**TED A. MATERA** has been named research engineer, Convair-Astronautics Division, General Dynamics Corp. Formerly he was with Westinghouse atomic power department, Westinghouse Electric Corp., as mechanical engineer.

**GEORGE E. ENGELMANN** has been named vice-president for administration, Mack Trucks, Inc. Formerly Engelmann served as executive assistant to the president of the company.

## Borg-Warner Promotions . . .



Norton



Schmal

**ROY NORTON** has been named director of engineering, Long Mfg. Division, Borg-Warner Corp. Norton, who previously served as assistant director of engineering and as transmission engineer, joined the Detroit Gear Division, (now a part of the Long Mfg. Division), Borg-Warner, three years ago.

**A. H. SCHMAL**, formerly sales manager of special products, has been made general sales manager of Long Mfg. Division, Borg-Warner Corp. Schmal has been associated with Borg-Warner divisions since 1953 in engineering and administrative capacities in the Detroit area.

**DANIEL W. LYSETT** has been made director of sales, Long Mfg. Division, Borg-Warner Corp. Formerly he was sales manager for the company. Lysett joined Long in 1942 and served as chief clutch engineer and director of product

## FORD MOTOR CO. CHANGES . . .

### Tractor and Implement Division . . .



**RAY J. MILLER** has been named chief engineer, Tractor and Implement Division, Ford Motor Co. He will be responsible for all engineering operations of the division and in charge of the company's Farm Machinery Research and Engineering Center in Birmingham, Mich. Miller joined Ford in 1953 and has served as manager, general engineering and research department, Tractor and Implement Division, since that time.



Formerly O'Harrow served as assistant chief tractor engineer of the division.

**CHARLES T. O'HARROW** has been made chief tractor engineer in charge of the tractor engineering department, Tractor and Implement Division, Ford Motor Co.

### ROBERT L. ERWIN

has been named manager of the newly designated engineering administration and services department, Tractor and Implement Division, Ford Motor Co. Erwin has been project engineer in the former general engineering department in charge of development of an experimental tractor powered by a free-piston turbine engine.



**N. N. NARAYAN RAO** has been made an assistant professor of Automobile Engineering, Madras Institute of Technology, Madras, India. Previously he served as a lecturer at the Institute.

**DAVID LEVITIN** has joined the Heli Coil Corp. as design engineer. Formerly he served as engineering draftsman with Essex Wire Corp.

**EDGAR RICHARD McPHEE**, formerly plant engineer, DeSoto Division, Chrysler Corp., is now materials handling engineer for the division.

Continued on page 108

## Obituaries

**JOHN V. BRAZIER** . . . (M'36) . . . operations manager, Dealers Refining Co. . . . served actively in SAE Mid-Michigan Section and on its Governing Board in several capacities . . . died Sept. 5 . . . born 1897 . . .

**EARL E. EBY** . . . (M'22) . . . retired in 1951 as manager, Power and Industrial Equipment, General Motors Overseas Operations . . . died Aug. 7 . . . born 1886 . . .

**WILLIAM G. GREEN** . . . (M'51) . . . service manager, Automotive Division, Canadian Car Co., Ltd. . . . joined the company in 1938 . . . died Aug. 28 . . . born in Scotland in 1897 . . .

**JOSEPH R. HILL** . . . (M'32) . . . technical sales promotion, Standard Oil Co., Inc., of Kentucky . . . served also with Standard Oil Development Co. . . . died May 3 . . . born 1905 . . .

**DAVID J. HLUBEK** . . . (J'54) . . . recently joined Caterpillar Tractor Co. as junior designer . . . graduated from General Motors Institute in 1954 with BSME . . . died July 18 . . . born 1930 . . .

**JOSEPH J. HUCHBEIN** . . . (A'48) . . . president, Hercules Machine Tool & Die Co. . . . had been president since 1936 . . . died July 8 . . . born in Yugoslavia in 1898 . . .

**PAUL JOHN LANSING** . . . (M'49) . . . design engineer, Air Logistic Corp. . . . formerly served as chief technologist, Thompson Products, Inc. . . . died Aug. 12 . . . born 1903 . . .

**D. GLENN MARTIN** . . . (M'50) . . . retired director of research and development for D-X Sunray Oil Co. . . . retired in May, completed 38 years in oil refining . . . died Sept. 10 . . . born 1890 . . .

**ERNEST L. MAXIM** . . . (M'26) . . . chairman of the board, Maxim Motor Co., Middleboro, Mass. . . . always asso-



**SAE PAST-PRESIDENT WILLIAM S. JAMES** and his son **WILLIAM R. JAMES** appear above. 1st Lieutenant William R. James is assigned to the 301st Bombardment Wing of the 4th Air Division of the 2nd Air Force. He is co-pilot of a KC-97 in the Air Refueling Squadron and is stationed at Barksdale Air Force Base near Shreveport, La. The younger James became a junior member of SAE in 1956. The senior James is active as head of William S. James & Associates.

**CHRISTY L. SPEXARTH**, chief engineer, Harley Davidson Motor Co., appears with his son, **FRANK SPEXARTH**, student at Marquette University. Frank is now serving as president of the SAE Student Club at Marquette.



ciated with his own company . . . died Aug. 8 . . . born 1886 . . .

**ROBERT S. MERITHEW** . . . (M'29) . . . auto engineer, A. E. Friedgen, Inc. . . . received BSME from Sheffield Scientific School, Yale University, in 1928 . . . died July 4 . . . born 1905 . . .

**RONALD PHILLIP PARKINSON** . . . (J'54) . . . project engineer, Champion Spark Plug Co. since 1953 . . . from 1949 to 1953 sales engineer with Toledo Steel Products Co. . . . died June 9 . . . born 1927 . . .

**ERVIN E. SCHIESEL** . . . (M'53) . . . vice-president, engineering and sales, Mattatuck Mfg. Co. . . . received Masters degree in Industrial Engineering from Columbia University in 1948 . . . died April 16 . . . born 1922 . . .

**FRANK W. SHARMAN** . . . (M'56) . . . project engineer, Bendix Westinghouse Automotive Air Brake Co. . . . received a BSME from University of Arizona in 1953 . . . died June 15 . . . born 1927 . . .

**FRANK GREGORY STEWART** . . . (A'35) . . . president, Standard Automobile Supply Co., Inc., and Stewart Mfg. Co. . . . one of the founders and first president, Automobile Old Timers of Washington D. C. . . . served as chairman (1949-50) SAE Washington Section . . . died Aug. 8 . . . born 1886 . . .

**ROYALE WISE** . . . (A'48) . . . chief engineer, Detroit Division, Thermoid Co. . . . had been with the company since 1940 . . . died Aug. 15 . . . born 1910 . . .

## SAE FATHERS AND SONS



COOPERATIVE ENGINEERING PROGRAM

NEWS

## Industry Voices Need for Ground Support Equipment Group

A UNANIMOUS desire to establish a permanent SAE aircraft committee on ground support equipment was expressed at a September meeting of industry and the services. R. A. Taylor of Convair acted as chairman of the 2-day meeting, which was held at the Transportation Supply and Maintenance Command in St. Louis, Mo.

Discussion reflected the possibility of committee work in the following areas:

- Exchange of technical information among prime contractors.
- Review of military specifications.
- Establishment of a line between flexibility and standardization.
- Cataloging of information on ground support equipment.

To determine ground support equipment needs, industry must be informed on weapon applications. The proposed committee would promote the exchange of technical information among prime contractors during the early stages of weapons development. Reduction of lead-time would result from committee efforts toward coordinating ground support needs with equipment manufacturers.

A retailing of military specification requirements to meet today's changing needs was proposed. Some of those present felt that certain existing requirements are not realistic. As a result, production costs are increased unnecessarily. The exploration of commercial airline support equipment was also urged.

One participant pointed out that support gear is sometimes more costly than the weapon itself.

Further discussion revealed that the Air Force has over 100 different types of gasoline combustion engines and that the Navy has over 60 variations of such engines. Consolidation and

standardization would promote more efficient handling and greater economy.

Three projects will be undertaken as a result of the St. Louis meeting. K. D. Sneed, Douglas Aircraft, will outline channels for intercommittee communication, and tabulate types of information which might be exchanged. W. E. Reese, Northrop Aircraft, will review the technical aspects in military specifications, and make a series of suggestions to committee members concerning alterations, simplification, and standardization. R. G. Lohmann, Martin Co., will develop a proposal on cataloging ground support equipment.

A broad cross-section of the aviation industry and the services attended the September 10-11 meeting. Present were Maj.-Gen. A. G. Hewitt, U. S. Air

Force; Brig.-Gen. W. B. Bunker, U. S. Army Transportation Supply and Maintenance Command; James Horan, Boeing Airplane; Elbert Kruger, Republic Aviation; Com. J. A. Laurich, U. S. Navy Bureau of Aeronautics; R. G. Lohmann, Martin Co.; J. W. Lucas, Lockheed Aircraft; L. C. Manasco, Hughes Aircraft; R. M. McClure, North American Aviation; W. E. Reese, Northrop Aircraft; K. D. Sneed, Douglas Aircraft; R. A. Taylor, Convair; R. P. Wisland, McDonnell Aircraft; Lt.-Col. R. L. Long, C. R. Wood, Jr., C. D. Stephenson, L. E. Bartley, L. G. Ruderer, R. C. Cropp, L. E. Ramey, and L. A. Neumoyer of the U. S. Army Transportation Supply and Maintenance Command; L. R. Hackney, Air Logistics Corp.; and M. L. Stoner, SAE Staff.

The desire of industry and the services to form a permanent committee on ground support equipment is now being considered by the Aeronautics Committee. Pending Aeronautics Committee approval, it is expected that this group will become a full-fledged SAE committee about the first of the year.

## Airplane Drafting Group Maps Future Activities



At the October meeting in Los Angeles, the Aeronautical Drafting Manual Committee's airplane group made plans for the development of SAE recommended drafting practices peculiar to the airplane industry. Shown above are: (l. to r.) Peter Folio, Grumman Aircraft Engrg. Corp.; Subcommittee Chairman J. A. Kabrud, Boeing Airplane Co.; and T. C. Pritchard, Lockheed Aircraft Corp.



A. E. Miller

## Oxygen Equipment Committee Holds First Meeting

A NEW SAE committee on Aircraft Oxygen Equipment (A-10) has been established to study existing oxygen equipment and to anticipate the future needs of industry and the services. At the committee's first meeting, held this fall in Los Angeles, Chairman A. E. Miller and his committee outlined the work which lies ahead. The committee will prepare recommended practices and design standards of oxygen equipment. It will collect and compile for publication quick-reference technical data pertaining to oxygen, oxygen equipment (gaseous or liquid), and their selection, installation, and performance in aircraft.

On problems of mutual interest, A-10 will collaborate with other SAE committees, especially Committee S-7 on Cockpit Standardization, Committee S-9 on Aircraft Safety, and A-9 on Air Conditioning. The group will also coordinate its activities with related activities of groups such as the Air Transport Association, Air Transport Association Medical Committee, Aircraft Industries Association, Airline Medical Directors Association, National Fire Protection Association, Compressed Gas Association, and the military services.

Current projects include the following:

- Compiling a comprehensive handbook (AIR 4A) on the selection, installation, and performance of oxygen

equipment for commercial transport aircraft.

- Collaborating with the National Fire Protection Association and the Compressed Gas Association on the drafting of "Safeguarding Aircraft Oxygen System Maintenance, NFPA No. 410B."

- Revising ARP 505, "Recommended Practice for Provision and Use of Oxygen in Commercial Transport Aircraft at Altitudes above 25,000 Ft."

- A-10 is considering the development of training material to acquaint cabin attendants and flight crews with fundamental facts pertaining to oxygen, oxygen systems, and the use of oxygen equipment.

Committee membership includes Chairman A. E. Miller, Scott Aviation; W. V. Blockley, North American Aviation; T. J. Cook, Lockheed Aircraft; E. G. Erickson, Capital Airlines; D. R. Good, Wright Field Aero Medical Laboratory; F. C. Hale, U. C. L. A.; W. P. Hannan, American Airlines; K. Hobein, Pioneer-Central Division, Bendix Aviation; C. W. Jonasson, Boeing Airplane; A. G. Lucking, British Overseas Airways; R. W. Maddock, Douglas Aircraft; G. F. Moore, Trans World Airlines; Dr. J. R. Poppen, Office of Naval Research; A. C. Princeau, United Air Lines; R. T. Stringer, Aro Equipment Co.; A. H. Tidd, Rand Development Corp.; W. H. Trammell, Lockheed Aircraft; and E. D. Witek, Convair.

committee. This group is also preparing a report on overall thermocouple system accuracy. An evaluation of the effects of changes in lead wire resistance due to changes in ambient temperature has been proposed.

The Nomenclature Subcommittee has been requested to develop recommendations for checking thermocouples and thermocouple systems in the field to determine suitability for re-use. The recommendations are to cover thermocouple harness and leads up to, but not including, the pilot indicator.

A supplement to an existing bibliography listing technical information on temperature measuring devices is being prepared by AE-2's Bibliography Subcommittee.

At a spring meeting of AE-2, a paper on response rates of thermocouples was presented by R. J. Moffat of General Motors Research Staff. The paper pointed out how the physical characteristics of the thermocouple junction affected response rate, and how the response rate of the thermocouple junction would be used to determine actual gas temperature at any instant during engine operation.

Chairman E. C. Schunke has called the next Temperature Measuring Devices Committee meeting for Feb. 4, 1958. At this time, the committee will visit General Motors' Gas Turbine Test Facilities in Detroit.

## News Briefs of SAE-ASTM Automotive Rubber Group

THE following news briefs result from a September 17-18 Detroit meeting of the SAE-ASTM Technical Committee on Automotive Rubber.

**Fluid Aging**—A fluid aging test program has been set up to show that misuse of additive fluids may have harmful effects on seals. Six to nine gear lubricants representing both the paraffinic and naphthenic types will be used. Tests will also include the use of four or five transmission fluids and of two to four motor oils. Additives will be identified as to general class.

Seal compounds will include a 70 durometer Buna N stock, an 80 durometer polyacrylate stock, an 80 durometer silicone compound, and possibly an 80 durometer Buna N compound.

**High Aromatic Content Gasolines**—A study of the effect of high aromatic content gasolines on rubber products is being made. Two nitrile rubber compounds and two neoprene compounds will be tested. A study of gasoline composition will also be made.

**Impact Testing**—An effort is being made to develop a relatively small piece of laboratory equipment to measure the fatigue life of a small specimen

## Temp Measurement Group Anticipates Future Needs

TEMPERATURE measurement system requirements of jet engines to be built five to ten years from now are being sought from Wright Air Development Center by SAE Committee AE-2, Temperature Measuring Devices for Aircraft Gas Turbines. The committee is also following the temperature measurement development contracts of WADC's Power Plant Laboratory where evaluations are being made of the Perkin-Elmer radiation pyrometer cell, the Bendix Aviation flexible chromel-alumel thermocouple harness, and the Dyna Empire resistant-type tempera-

ture sensor system. AE-2 members expect to hear a report on the above at their next meeting as well as reports on General Electric and B. G. Corp. temperature sensing contracts.

In addition, information on chromel-alumel thermocouples in combustion atmospheres in the 1800-2000 F range is being gathered by AE-2's Technical Subcommittee.

Requirements for thermocouple connectors and for the mounting of resistance temperature detectors used for oil and bearing temperatures are being studied by the Mechanical Design Sub-

of rubber subjected to repeated impact at constant energy. It is hoped that the results from such a laboratory test will correlate with results of tests on full-size bumpers.

**Tear Testing**—Tear resistance values in pounds-per-inch obtained on Die-B for natural rubber and GR-S compounds only were circulated to those present. Data were confined to actual commercial compounds of five different hardnesses (40 to 80) and in four tensile strength groups (500-1000, 1000-2000, 2000-3000, 3000-4000 psi). The compounds were confined to those meeting the R Table requirements. The above is being studied in an effort to develop values for tear testing.

## Data Sought on Turbojet Engine Testing

**SOLUTIONS** to aircraft engine test data are being sought by the Engine Division's Engine Test Study Panel. At the panel's first meeting held in September at Wright-Patterson Air Force Base, it was revealed that initial study will be centered upon turbojet engines. Studies of turboprop and turboshaft engine types will be held in abeyance pending results of the turbojet study.

Panel members have been requested to prepare reports on the following items. Compilation of this material will form the basis of panel recommendations to SAE's Aircraft Engine Division as to the future efforts of the panel.

- Types of test cells—Brief sketches or drawings showing a cross-section outline of the test cell have been requested. Location of air flow filters, orifices, inlet ducts, baffle wall, secondary air flow, floor, tailpipe seal, augments, muffler, and thrust meter with relation to the engine should be indicated.

- Types of equipment used to measure factors affecting engine performance, such as thrust, fuel flow, exhaust gas temperature, and inlet temperature.—Information is being sought on the methods of calibrating those pieces of equipment which appreciably affect engine performance figures.

- Methods of running test stand correlation tests—Effect of afterburning and variable geometric features will be evaluated. Test schedules, methods, and frequently of running such test correlation programs will be considered.

- Test stand programs and fixes.

- Suggestions for test stand correlation improvement.

Test panel members include the following: Chairman E. L. Anderson, Allison Division; W. D. Anderson, Wright Aeronautical; E. A. Clifford, Orenda Engines; W. B. Flanders, Fairchild Engine; H. S. Jordan, Westinghouse Electric; F. J. Rodgers, General Electric; and M. S. Saboe, Lycoming-Stratford.

## Technishorts . . .

**A PROTOTYPE TEST CELL** using the rail concept for a 30,000-lb dressed jet engine was reported on by W. Tepper, BUAER, at a meeting of the Tooling Subcommittee of SAE Committee E-21, General Standards for Aircraft Engines. The test cell is designed to measure performance rather than engine function. It was also reported that, on a Congressional directive, a joint Navy-Air Force 40,000-lb test cell is being developed.

**AN ENGINE TEST CODE SUBCOMMITTEE** has been reactivated by J. F. Greathouse, chairman of SAE's Engine Committee. It will revise, as necessary, test code requirements for gasoline engines, and will incorporate technical information to cover all spark-ignition engines, taking into consideration multiple fuel engines. Efforts are being made to relate the activities of the reactivated group with those of the Diesel Engine Test Code Subcommittee.

**REVISION OF THE AIR-BRAKE HOSE STANDARD (SAE 40R2)** provides for two new grades of wire braided air-brake hoses. To improve burst pressure, a minimum OD of 1/2 in. and a maximum of 9/16 in. is prescribed.

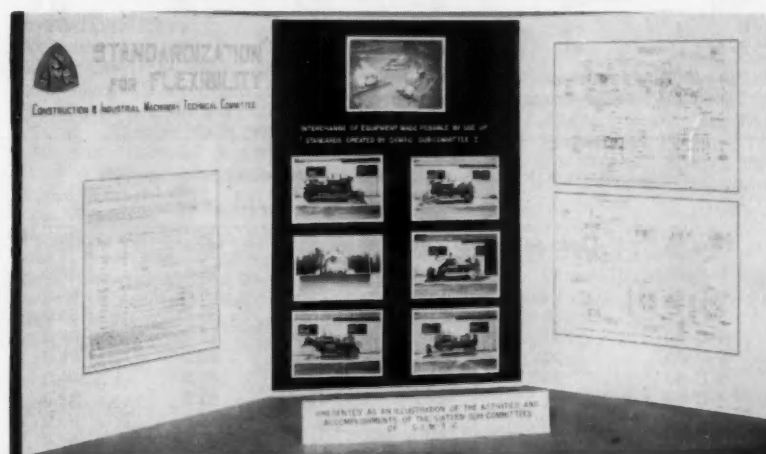
**HYDRAULIC DIRECTIONAL CONTROL VALVES 3000 PSI MAXIMUM**, a new SAE Recommended Practice, establishes a port area to flow relationship. It matches valve spool eye-ends in relation to rated capacity. The new report complements an existing SAE test code for hydraulic control valves.

**THE NEW CODING OF FITTINGS SUBCOMMITTEE** is determining the feasibility of establishing a coding system for automotive, refrigeration, marine, and hydraulic tube fittings. R. W. Phillips is chairman of the subcommittee which held its first meeting in Detroit October 1. The new group is part of SAE's Tube, Pipe, Hose, and Lubrication Fittings Committee.

**SAFETY PROVISIONS FOR CREW MEMBER STATIONS** are being studied by SAE Committee S-9, Cabin Safety Provision. The committee is also studying delethalization of aircraft cabins and their components.

**REVISION OF THE AUTOMOTIVE RUBBER MATS STANDARD (SAE 80R)** includes the addition of procedures for the physical testing of elastomeric color coatings.

## CIMTC Display Group Completes First Project



The above display represents the first completed effort of the Display Subcommittee which the Construction and Industrial Machinery Technical Committee put into action last March. The purpose of the subcommittee is to develop material which will call the attention of both SAE and outside technical personnel to the nature and extent of various CIMTC activities.

# Octane Number Requirements For 1955 Cars Studied by CRC

**R**ESULTS of a survey on octane number requirements of selected 1955 passenger car models are presented in CRC report 300. Although test methods were similar to those used in the 1954 survey, a new method of plotting the distribution curves was used. 1955 distribution curves were raised over those recorded in the 1954 survey by approximately 0.5 and 1.0 octane numbers at the 50% and 90% satisfied points, respectively.

Maximum octane-number requirements of thirteen car models having new design engines and/or transmissions were studied in relation to two types of reference fuels. (See Table 1.) The first was a primary fuel containing isooctane and normal heptane blended in two octane-number increments from 80 to 100. The second type

consisted of full-boiling range fuel blends prepared by cross blending three gasolines in the same octane-number increments as the primary fuel.

A summary of the survey follows:

- Thirty laboratories submitted data on a total of 357 cars. Thirteen 1955 models with V-8 engines representing ten makes were included.

- Maximum octane-number requirements were expressed in terms of trace knock due to either spark knock or surface ignition. The average octane number ratings of these fuels as determined by 10 of the participating laboratories and the fuel identification numbers are given in Table 2.

- A comparison of data from a 1954 survey on five of the same makes tested

in 1955, showed an increase in requirements of the 1955 over the 1954 models from one to seven octane numbers based on 50% of the cars satisfied.

- Octane-number requirement distribution curves for the eastern and central geographical areas in the U. S. were almost identical, despite the difference in octane numbers of gasolines being marketed in these areas.

- Percentage of cars which gave maximum combustion knock at part-throttle varied from 0% for makes P-A and D to 60% for make I.

- Owners reported data on the tank fuel in 347 of 357 cars. Of the 347 cars, 23% of the owners reported knock with the tank fuel while 27% of the cars were found to give knock by the test observers.

- The Research and Motor method ratings of the tank or optional gasolines giving borderline knock in 64 cars were in close agreement with the maximum requirements of these same cars measured with full-boiling range reference fuels. This result indicated that the full-boiling range reference fuels are representative of commercial gasolines.

CRC report 300, "Octane Number Requirement Survey," contains 74 pp. including tables and graphs.

To Order CRC No. 300 . . . on which this article is based, see p. 5

Table 1—Maximum Octane-Number Requirements

Make	No. Cars Tested	Octane Number for Indicated Per Cent Satisfied			
		50%		90%	
		PR <sup>a</sup>	FBR <sup>b</sup>	PR <sup>a</sup>	FBR <sup>b</sup>
L-2	27	93	93.5	95.5	96.5
S	26	92.5	93.5	94.5	96
I	28	92	92	96.5	96.5
D	31	91.5	93	94	95.5
M	25	91	92.5	95	96
N-M	26	90.5	91.5	94.5	95
O-1	23	90	92	93.5	94
G	28	89.5	90.5	93	93.5
O-M	25	88.5	90	91.5	93.5
N-A	27	88	89	91	93.5
P-M	24	88	89.5	91	92.5
H	30	86	88	88.5	90
P-A	37	85.5	88	89	92

<sup>a</sup> PR = Primary reference fuels.

<sup>b</sup> FBR = Full-boiling range reference fuels.

Table 2—Average Octane Number Ratings and Fuel Identification Numbers

Blend No.	Composition vol % average octane no.			
	RMFD-64-65	RMFD-63-55	RMFD-62-55	
1-C-55	99	1		Motor
2-C-55	84	16		75.6
3-C-55	68	32		76.9
4-C-55	51	49		78.1
5-C-55	32	68		79.4
6-C-55	12	88		80.7
7-C-55		92	8	81.9
8-C-55		73	27	83.2
9-C-55		51	49	84.4
10-C-55		29	71	86.0
11-C-55		6	94	87.7
				89.4
				100.0

## Hansen New Chairman Of Small Engines Group

**E.** T. Hansen of the Outboard Marine Corp. took over as chairman of the SAE Small Aircooled Gasoline Engine Subcommittee at a September meeting. Mr. Hansen succeeds Peter Altman who is presently advisor to SAE President Eddy on the small engines field.

Present projects of the subcommittee include:

- Output shaft and flange dimension for 2- and 4-stroke cycle gasoline engines. Applications cover rotor lawn mowers, pumps, generators, and belt drives.

- Interchangeable bolt circle patterns for recoil starter mountings.

- Taper on flywheels.

The subcommittee recently participated in the planning of the program for the Production Forum held in conjunction with the National Farm, Construction, and Industry Machinery Meeting held in Milwaukee. Subjects discussed at the Forum were:

- Plating aluminum cylinder walls.

- Use of self-tapping studs and inserts in die castings.

- Small engine crankshaft production techniques.

# SAE

## Section

# Meetings

### BALTIMORE

**December 12** . . . Fuels and Lubricants Meeting. Speaker William Kaplan, director of automotive research, American Oil Company, Baltimore, Md.—“The Florida International 12 hr. Grand Prix of Endurance.” 6 West Fayette St., Baltimore. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Color film of 1957 Sebring Race.

### CENTRAL ILLINOIS

**November 25** . . . “Taconite.” Pére Marquette Hotel, Peoria. Dinner 6:30 p.m. Meeting 7:45 p.m.

### CHICAGO

**November 18** . . . William E. Rice, automotive engineer, Clark Equipment Co., Buchanan, Mich.—“Air Springs as Applied to Commercial Carriers.” Bronze-wood Room, Hotel LaSalle, South Bend, Ind. Dinner 6:45 p.m. Meeting 8:00 p.m.

**December 10** . . . Calhoun Norton.—“To Europe and Back by Cessna.” Hotel Knickerbocker, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Features: Film on “Vertijet” airplane. Social Half-Hour 6:15 p.m. to 6:45 p.m. Ladies especially invited.

### INDIANA

**December 12** . . . K. Beier, vice-president in charge, engineering & research, Schwitzer Corp., Indianapolis.—“Diesel Engine Turbochargers.” Indianapolis Naval Armory. Cocktail Hour 6:30 p.m. Meeting 8:00 p.m.

### METROPOLITAN

**November 14** . . . W. E. Bettoney, E. I. du Pont de Nemours & Co., New York.—“Carburetor Icing.” Roger Smith Hotel, 47th St. & Lexington Ave., New York. Luncheon 12:00.

**November 14** . . . Student Activity Meeting. Speaker C. Gordon Benett, Jaguar Cars, North American Corp.—“Sports Car Racing.” A film of the 1957 Sebring Races will be shown. New York University, University Heights, Bronx, New York. Meeting 7:45 p.m.

**December 12** . . . Transportation &

Maintenance Meeting. Speaker Charles O. Slemmons, General Tire & Rubber Co.—“Air Suspension in Commercial and Passenger Cars.” Brass Rail Restaurant, Fifth Ave. between 43rd and 44th Sts., New York. Dinner Meeting.

### MONTREAL

**November 18** . . . Mount Royal Hotel. Dinner 7:00 p.m. Meeting 7:45 p.m.  
**December 5** . . . Special Feature: Ladies Night. Mount Royal Hotel.

### NEW ENGLAND

**November 12** . . . Danforth K. Heiple, chief field engineer, LeTourneau-West-inghouse Co., Peoria, Ill.—“Principles of Earth Moving with Scraper Equipment.” M.I.T. Faculty Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

### NORTHERN CALIFORNIA

**November 20** . . . Transportation and Maintenance Meeting. Panel of Speakers. Engineers Club, San Francisco. Dinner 6:30 p.m. Meeting 8:00 p.m.

### PHILADELPHIA

**November 13** . . . Paul H. Richard, automotive technologist, E. I. du Pont de Nemours & Co., Detroit.—“Cars of the Future.” Engineers Club of Philadelphia. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Feature: Student Night. Coffee Speaker Norman G. Shidle, Editor, SAE Journal.—“Technical Writing.”

**December 11** . . . John D. Caplan, assistant head, fuels & lubricants department, General Motors Research Staff, Detroit.—“Air pollution.” Engineers Club of Philadelphia. Dinner 6:30 p.m. Meeting 7:45 p.m.

### PITTSBURGH

Fridays from 7:30-8:00 p.m. through November and December. “Your Auto & You.” Metropolitan Pittsburgh WQED-TV, Channel 13. See program listing in “Rambling through the Sections,” page 104.

### SOUTHERN CALIFORNIA

**November 18** . . . Aircraft Meeting —“Jet Transports.” Speakers from United Airlines and PAA. Roger Young Auditorium, Los Angeles.

### SOUTHERN NEW ENGLAND

**November 13** . . . Joseph C. Johnson, staff assistant to vice-president, American Bosch Division, American Bosch Arma Corp., Springfield, Mass.—“Watt-Muscles in the Modern Automobile.” Meeting location: American Bosch Arma Corp. Dinner 6:45 p.m. Meeting 8:00 p.m.

**December 12** . . . E. Byrket, assistant manager of standards, Industrial Products Division, Sheffield Corp.—“The Science of Measurement.” Hartford Golf Club, Hartford.

### SPOKANE-INTERMOUNTAIN

**November 12** . . . George R. MacKay, chief engineer, Dynamometer Division, Clayton Mfg. Co.—“The Use of the Dynamometer, both chassis and engine type for engine tune-up and performance.” Cocktails 6:30 p.m. Dinner 7:00 p.m. Meeting 8:00 p.m.

### ST. LOUIS

**November 12** . . . Charles Wilhite, assistant sales manager, New Products, Cummins Diesel Engine Co., Columbus, Ind.—“The Case for the Diesel Engine.” Congress Hotel. Dinner 7:00 p.m. Meeting 7:45 p.m.

**December 10** . . . Wren Malone, St. Louis Shipbuilding & Steel Co., St. Louis, Mo.—“Vapor Phase Engine Cooling.” Congress Hotel. Dinner 7:00 p.m. Meeting 7:45 p.m.

### TEXAS

**November 22** . . . Aircraft Transportation Meeting.

### TWIN CITY

**December 11** . . . Carl Bachle, vice-president of research, Continental Aviation & Engineering Corp., Minneapolis.—“Air Cooled Diesel Engines.” Hasty Tasty Restaurant. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Field trip through Consolidated Freightways.

### WESTERN MICHIGAN

**December 3** . . . Annual Grand Rapids Meeting—“Aircraft.” Dinner 7:00 p.m. Meeting 8:00 p.m.

### WICHITA

**November 14** . . . Gregg Knowles, project engineer, Stratos Division of Fairchild Engine & Airplane Corp., Bayshore L. I., N. Y.—“An Integrated Air Conditioning System for Transport Aircraft.” Innes Tea Room. Dinner 6:30. Meeting 8:00 p.m. Special Feature: Social Hour.

Rambling . . .

## THROUGH THE SECTIONS

**A**n all-movie meeting, staged by the Williamsport Group was an unusual event of this year's early Fall period. . . . Several Sections opened their 1957-58 activities with plant-tour meetings. But, in more cases than not, the September sessions which began the Section year were attacks on currently acute technical problems.

The **WILLIAMSPORT** film festival lasted about one and one-half hours and had technical fare for both ground vehicle and aeronautical engineers. . . . Four films were presented: "Aberdeen Proving Ground"; "Dial 47-J—Bell Helicopter"; "Farnborough Air Show"; and "Midget Auto Racing." . . . **CINCINNATI, CLEVELAND** and **ST. LOUIS SECTIONS** were among those which opened with plant tours. . . . The St. Louisians were interested to see how many different operations are necessary to produce an every-day tin can (at Continental Can Co.) . . . the Evendale plant of Armco Steel Co. was the destination of chartered buses filled with Cincinnati Section members on Sept. 23. . . . Cleveland members, 200 strong, visited the Avon Lake Plant of the Freuhauf Trailer Co. . . . Way back on July 30, the SAE Student Branch at General Motors Institute visited Chevrolet's Flint V-8 engine plant . . . and (see photograph below) listened to Chevrolet speakers following a buffet supper. . . .



. . . speakers are, left to right, Messrs. D. Rice, Borror, and A. Close.

Abridgements of Section papers, incidentally, are now getting into SAE Journal regularly within 60 days following receipt of the paper in New York. . . . Preprints of the full papers are available, of course, within two weeks. . . .

Represented on other pages of this issue by contributions to Society's technical literature (in the form of abridgements of papers presented at recent meetings) are the following Sections: Detroit-p. 55; Canadian-p. 56; Twin City-p. 62; Metropolitan-p. 52.



The fourth annual Automotive Air-Conditioning Meeting, largest of the year for the **TEXAS SECTION**, (part of the crowd pictured above), was the first of the season and provided a forum for discussions mainly of air-conditioning compressors and controls. . . . Guest speaker George Taubeneck, editor and publisher of the *Air Conditioning and Refrigeration News*, told the closing dinner meeting that fast-developing advancements in the general fields of metallurgy, new sources of power, and the new procedures involving all of them offered the air-conditioning industry opportunity to utilize this new progress for its own benefit. . . . 16 independent

manufacturers and all automobile manufacturers, which install air-conditioning in original equipment, submitted exhibits. . . .



TAUBENECK

The "kick-off" meeting of the **NEW ENGLAND SECTION** was held October 1. . . . "Plastics as Automotive Engineering Materials" was the subject of the guest speaker, Dr. J. D. Young, of E. I. du Pont de Nemours & Co. The use of plastics by design engineers and stylists in the automotive industry was described and numerous examples of applications in the current models were illustrated with colored slides. Young displayed many samples of "hardware" which afforded the members and guests an opportunity to actually see many of the items covered in the paper . . .

Latest issue of **CENTRAL ILLINOIS SECTION'S** "Newsletter", in addition to an attractive new photo offset format, had this wisdom to impart:

"The amount of friction you create isn't a measure of how fast you're going. . . . Dragging your feet will create friction"

Central Illinois, incidentally, has **TWO** Student Activity Chairmen . . . one each to oversee activities at Bradley University and University of Illinois. . . . Caterpillar's A. M. Kaiser is the Bradley patron; Caterpillar's W. I. Nelson for U of I. . . .

**PITTSBURGH SECTION'S** TV series—a first in SAE history—actually went on the air at 7:30 p.m. on Friday, Sept. 27 . . . and will continue at the same time each week through December. (Metropolitan Pittsburgh WQED-TV, Channel 13). . . . Past Section Chairman Murray Fahnestock is chairman of the Section's TV Committee which developed and arranged for the programs. Helping him were Court Wolfe, as vice-chairman; and W. G. Stanier as secretary. . . . Title of the series: "Your Automobile and You"; Moderator, SAE Past-President R. J. S. Pigott. . . . Stated purpose of the Pittsburgh TV series is "to promote a better understanding between the automobile and its driver-owner . . . and to work in something—sidewise or upside down—to show what the SAE means to the car owner." . . .

The thirteen subjects for the series are: (1) Development of Early Cars; (2) Electrical Systems; (3) Brakes; (4) Springs and Shock Absorbers; (5) Engines; (6) Fuels; (7) Lubricants; (8) Carburetors and Fuel Injection; (9) Tires; (10) Transmissions and Axles; (11) Handling; (12) Appearance; and (13) Maintenance . . . Messrs. Pigott and Fahnestock themselves presented the initial program. . . .

**OLIVER K. KELLEY**, newly named chief engineer of Buick, was chairman of **DETROIT SECTION'S WHITE SULPHUR MEETING** this year. . . . Attendance was bigger than ever, ladies as charming and numerous. . . . One of two technical sessions talked of dreams about Dream Cars . . . the other revealed hitherto unexplored applications of hydraulic, electrical, and pneumatic systems. . . . The accent was on the future! . . .

Speakers of the first session appear below, left to right, P. C. Mortenson, of Vickers, Inc., speaking on Hydraulic Systems; Vaughn H. Hardy of Delco Application Division, GMC, speaking on Electrical Systems; and Stephen Johnson Jr. of Westinghouse Automotive Air Brake Co., speaking on Pneumatic Systems.



Listeners at the "Dream Car" session went away asking for copies of a poem, written by Mrs. J. W. Collins, Jr., and read by Session Moderator C. C. Dybvig. . . . Here it is:

*A lot of car suits me to a "T"  
If the length means more room for my  
family and me.  
With plenty of space for baggage and boys  
Who refuse to leave home without half of  
their toys.*

*But remember that cars must still be  
parked  
In spaces too small for an oversized "Ark."  
So let's not add length for length's sake  
alone  
If you can't park your bus, you end up  
back home.*

*Now sleek and low is the current design,  
One lovely to look at any old time.  
But people are getting taller, you know,  
And the question now is "How low can  
cars go  
'Fore we sit on the floor, with our legs  
straight ahead  
Wishing to heaven we'd stayed home in-  
stead?"*



Leaders of Detroit "Your Dreams for a Dream Car" session appear above, left to right, C. C. Dybvig, moderator; V. M. Exner, speaker; A. A. Kucher, chairman; E. E. Anderson and R. H. Maguire, members of the panel with Exner.

**ATLANTA SECTION** opened its 1957-58 year with a presentation about the importance of the petroleum industry in our daily living—which had previously won for its author three important awards. The presentation: "The Magic Barrel" . . . the author: Pure Oil's Joe W. White . . . the awards: the DuPont Award and two silver awards from the American Petroleum Institute. . . .

Reported to be the first of its kind, a communique from the **TWIN CITY SECTION** chairman to members of the Governing Board on a "monthly" (regular) basis has been initiated . . . designed to keep GB members informed on current TC Section affairs "when a meeting does not seem warranted or is not convenient." . . .

A newly-appointed Program Steering Committee, named by Section Chairman Maurice A. Hutelmyer and headed by Leon F. Dumont of DuPont, has put **PHILADELPHIA SECTION** in the growing list of Sections whose meetings are scheduled ahead for the entire Section year. . . . The Quakers

started off in October with Gregory Flynn's popular paper on "Free Piston Engines" and will end next May with their annual Ladies Night at Swarthmore's Springhaven Country Club. . . . Six technical meetings are detailed for the months ahead. . . .

**METROPOLITAN SECTION** Governing Board presented their Certificate of Appreciation to 1956-57 Chairman **CHARLES E. CHAMBLISS**, not to Charles E. Chamberliss, as the October issue erroneously stated.



Frank R. Heath, (left), of Westinghouse Electric Corp., addressed **KANSAS CITY SECTION** at their September meeting on "The Use of High Speed Computers in Solving Supersonic Jet Engineering Problems." Heath discussed how high-speed computers may be used in solving current big business problems.

Special guests at the opening meeting of **SOUTH BEND DIVISION** of the **CHICAGO SECTION** included high school students who are prospective college students for the field of automobile engineering. . . .

Appearing below are the speakers of the evening and Section officers, left to right, Ralph Handy, vice-chairman of South Bend Division, W. A. Gebhardt, Chicago Section chairman, W. C. Suttle, and F. C. Mock, speakers on "Automotive Fuel Injection," and Martin Stamm.



# RAMBLING through the SECTIONS

continued . . .

Repeats of papers presented at the SAE West Coast Meeting were heard by the **INDIANA** and **SPOKANE INTERMOUNTAIN SECTIONS** at their September meetings. GMC's H. C. Kirtland, chief engineer, Allison Division's transmission applications, spoke on "Automotive Transmissions in Heavy Duty Trucks" at the Indiana meeting.



KIRTLAND

. . . Henry Ard of Potlatch Forests, Inc. opened the Spokane Intermountain Section season with his paper of "Friction Brake Limitation in Logging Truck Service" . . . the second meeting of the Spokane Section, held October 23, featured Homer T. Seale, president of Homer T. Seale, Inc., speaking on "Brake Balance Between Axles—Original Design and Field Correction" . . .

**CANADIAN SECTION** Secretary George R. Jackson is rightfully concerned about SAE Journal's grandiose garbling of his address in the list of 1957-58 Section officers on p. 52 of its September issue. . . Secretary Jackson—and the Canadian Section—still have their headquarters in Toronto; **NOT** in "Yotonyo", as the Journal incredibly stated. . .



DAVIDSON

The **SOUTH TEXAS GROUP** was addressed by T. F. Davidson of the Propulsion Laboratory, Wright Air Development Center, USAF's Air Research & Development Command, at their September meeting. The subject was the development of present day gas turbine fuels and oils . . .

opment Center, USAF's Air Research & Development Command, at their September meeting. The subject was the development of present day gas turbine fuels and oils . . .



KINGSBURG

Harold Kingsburg, chief engineer of Chrysler Corp.'s Los Angeles plant, was guest speaker at the October meeting of the **SOUTH BAY DIVISION, NORTHERN CALIFORNIA SECTION**. . . his topic was "Chrysler Torque Flite Transmissions" . . .

Worth H. Percival of GMC's Research Staff addressed the **DAYTON SECTION** on October 10. Percival detailed the history, development and present status of free piston engines, and included a discussion of the GM XP-500 car, illustrated with slides and a film.

"Project Vanguard and Inevitability of Space Travel" was the topic covered at the September meeting of the **TWIN CITY SECTION**—a "Father & Son" evening. Speaker was Watt Myers, project engineer, armament section, Aero Division of Minneapolis-Honeywell Co. The paper explained the satellite portion of the U. S. participation in the International Geophysical Year . . . the Vanguard Rocket and its guidance system. Shown below, left to right, viewing a mock-up of the guidance system for the Vanguard Rocket are Albert L. Preston, Twin City Section vice-chairman; Stanley Snow, Systems Engineer of the Vanguard program; David Preston; George Preston; Watt Myers, speaker of the evening; and Jim Preston.



## WASHINGTON SECTION

at its September meeting, heard J. T. Cosby, (right), describe the configuration, performance, structural development and weapon-system management of the world's first supersonic bomber. . . Convair's B56. Cosby is program director for the B56 project.



**EUGENE J. MAGANIELLO** (right) is welcomed as incoming chairman of the **SAE CLEVELAND SECTION** by outgoing chairman **ALBERT D. GILCHRIST**. Maganiello is affiliated with the Lewis Flight Propulsion Laboratories, NACA.

from

# SECTION CAMERAS



Barrett Russell (above left) is shown with his co-worker at E. I. du Pont de Nemours & Co., John Kelly (middle), and Dan Pettit (right) of Thompson Products, Inc., at the **TEXAS GULF COAST SECTION'S** September meeting. Kelly, Section membership chairman, tells Pettit of the benefits available to SAE members. . . Pettit's application is "in-the-mill."

★ ★ ★



R. K. Polak, second from right—above, is congratulating Harry Chesebrough on his address before the **CENTRAL ILLINOIS SECTION**, September 16. Joining in the congratulations are, left to right, R. D. Henderson, past chairman, Rhodell Owen, coffee speaker, and Harry Fall, technical chairman.

★ ★ ★

At right are leaders of the **DETROIT SECTION** and its White Sulphur Meeting. L to r: J. P. Charles, in charge of the meeting technical sessions and Section vice-chairman; M. J. Kittler, Section chairman; O. K. Kelley, White Sulphur Meeting chairman; and K. E. Coppock, chairman of the first technical session on Automated Automobiles-Trends in Power Assists.



★ ★ ★



**INDIANA SECTION** officers and staff for the 1957-58 season are shown on the left. Seated left to right: M. E. Estey, treasurer; W. M. Horner, vice-chairman; E. S. Witchger, chairman; D. D. Don Carlos, secretary; S. Wilder Jr., past chairman . . . standing, left to right, W. A. Lane, arrangements; O. C. Cromer, students; M. D. Parker, publicity; A. W. Christy, reception; R. M. Tuck and J. Creamer, meetings; B. A. Woodhull, field editor.

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**About SAE Members**

Continued from page 98



Wright

Mason

Eshelman

Wolff

Olson

**DALE WRIGHT**, formerly chief metallurgist of Caterpillar Tractor Co., has been made manager of the company's reorganized quality control department. Wright joined Caterpillar in 1934 and became metallurgist staff engineer two years later.

**CLAUDE R. MASON**, general service manager, B. F. Goodrich Tire Co., has celebrated his 50th year with the company. Mason joined the company at 14 years of age and served in various capacities, including operating manager of the Detroit sales district, assistant manager of the Akron service department, manager of the Los Angeles service department, and general sales manager of all tire service operations since 1930.

**RALPH H. ESHELMAN** has been made Engineering editor of "The Iron Age." Formerly Eshelman served as associate editor of "The Tool Engineer Magazine."

**CARL K. WOLFF** has been made western regional sales manager of W. S. Shamban & Co. Formerly he was senior sales engineer and division product coordinator of the National Seal Division, Federal-Mogul-Bower Bearings, Inc.

**THEODORE E. OLSON** has formed a manufacturers agency to provide metallurgical and engineering sales representation to the industry of Michigan. Initially he will represent the

Alloy Engineering Co. of Berea, Ohio. For the past 10 years Olson has been a sales engineer with the Tocco Division of the Ohio Crankshaft Co.

**JOHN K. ZAISER** has been made an assistant professor of Mechanical Engineering at California Polytechnic College, San Luis Obispo, Calif. Formerly Zaier was a designer with Anacanda Co.

**ROBERT M. STRIETER** has become a commander, U. S. Navy, and is now located at the Industrial College of the Armed Forces, Washington, D. C. Formerly he was a staff officer with Commander Fleet Air Wing Eleven, Naval Air Station, Jacksonville, Fla.

**JAMES A. BLACK** has become a teaching associate at Indiana University, School of Business, management department. Prior to his new post, Black served as manager, tube production engineering, Radio Corp. of America. He is a candidate for a Doctors Degree in Business Administration, having received a Bachelors Degree in Mechanical Engineering from General Motors Institute in 1950 and a Masters Degree in Business Administration from Xavier University in 1957.

**JOHN B. O'DONOGHUE** has been made field sales manager of the Cleveland Pneumatic Tool Co. Formerly he was assistant general sales manager for the company.

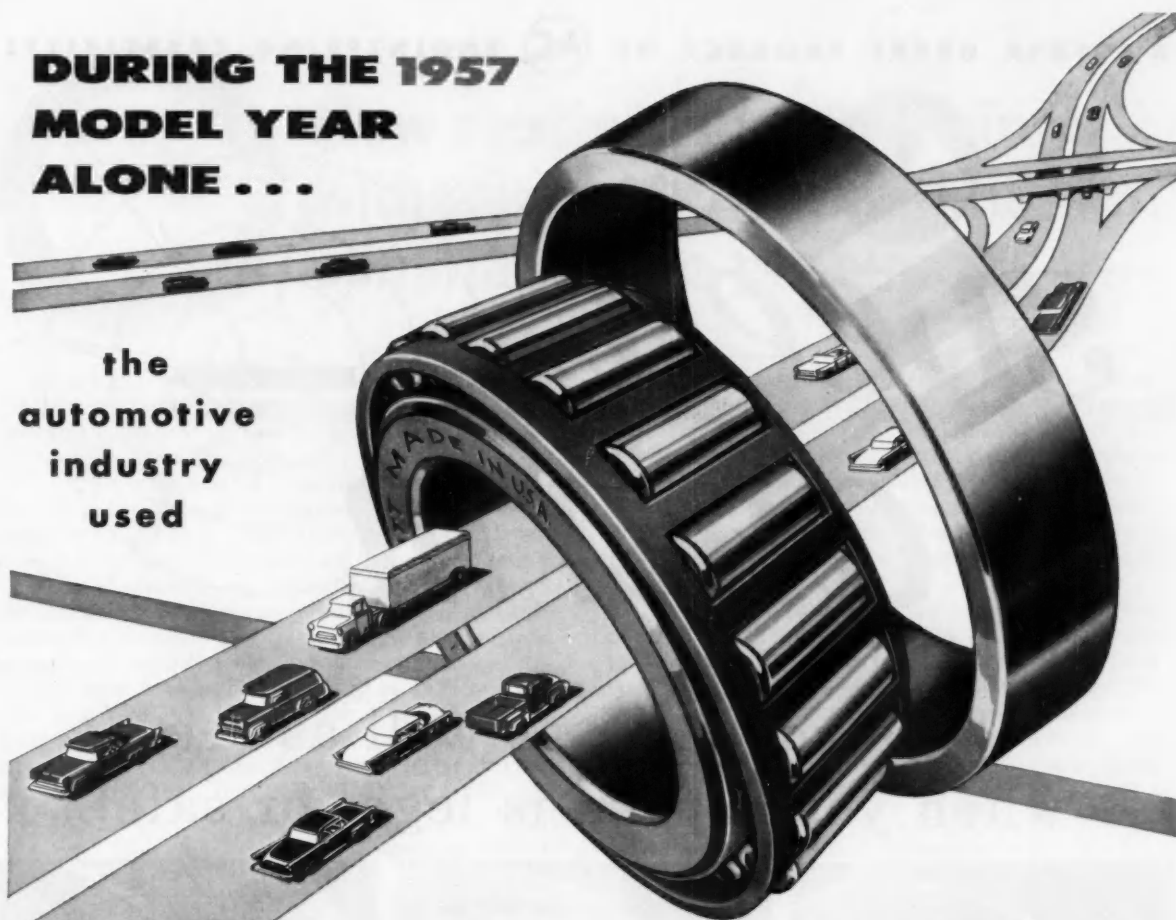
Continued on page 112



**JOSEPH GESCHELIN**, Detroit editor, *Automotive Industries* (second from left) returned recently from a trip to the Orient during which he conferred with leading engineers. Upon arrival in Yokahama he and Mrs. Geschelin were met by the group of Japanese engineers of Nissan Motor Co. and General Motors of Tokyo shown in the photograph.

**DURING THE 1957  
MODEL YEAR  
ALONE . . .**

**the  
automotive  
industry  
used**



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Tapered Bearings*

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Today HYATT's new electronically-controlled production lines are turning out *millions* of tapered bearings with greater uniformity than ever before achieved in quantity production. These advanced manufacturing techniques, plus traditional HYATT craftsmanship, assure longer, smoother, more dependable performance in your toughest automotive applications. Hyatt Bearings Division, General Motors Corporation, Harrison, N.J.; Pittsburgh; Detroit; Chicago; Oakland, California.

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**FOR CARS AND TRUCKS**

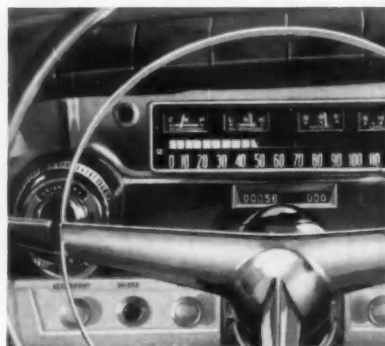


ANOTHER GREAT PRODUCT OF **AC** ENGINEERING CREATIVITY!

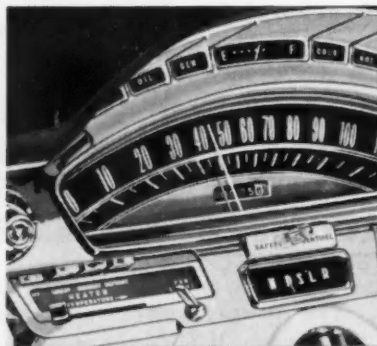
# *speed* *alarm*



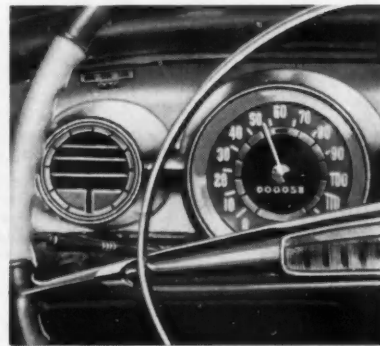
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when your speed is legal or safe!



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"SAFETY BUZZER"



OLDSMOBILE for 1958 calls it the  
"SAFETY SENTINEL"



PONTIAC for 1958 calls it the  
"SAFEGUARD"

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AC, always vitally interested in working for safety, is specially proud of the great forward stride taken when AC engineers developed the pre-set speed alarm, making it possible for the driver to set the legal or safe speed he wants to observe so that a buzzer warning will occur when that speed is reached.

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today on 1958 Buick,  
Oldsmobile and Pontiac



## New resilient clutch facings withstand 400 psi and higher, eliminate fade problems

A new group of resilient friction materials that eliminate the problem of permanent and progressive fade—at pressures up to 400 psi and above—have been created by Armstrong research engineers.

The high coefficient of friction of these new compounds remains nearly constant through many thousands of engagements, maintaining their original performance characteristics for the life of the transmission.

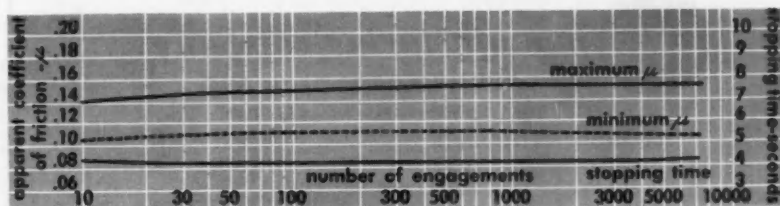
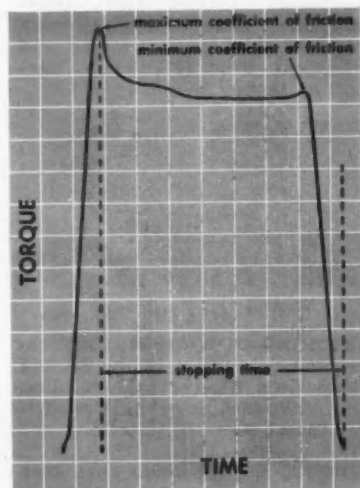
The new materials were specially developed to meet the demands of modern automatic transmissions where increased horsepower and design changes have imposed greater loads on facing materials than ever before.

They have been used successfully in 1957 automobiles and have been approved for even wider use in 1958 models. In experimental transmissions with closing pressures of 2000 psi, these new compounds show virtually no friction loss under severe test conditions.

The new materials are made by an exclusive patented process that combines organic and inorganic fibers with special synthetic saturants. The resulting compounds provide smooth engagement characteristics combined with high torque capacity and long wear. They were designed for use at the higher ambient temperatures found in today's automatic transmissions, and are not affected by the much higher flash temperatures that occur during engagement.

In tests run at the Armstrong Research and Development Center, the new compositions show a remarkable improvement over other resilient materials that have been used in millions of automatic transmissions. For performance data on these new materials, write for your copy of booklet IND-953. Address Armstrong Cork Company, Industrial Division, 7211 Durham Street, Lancaster, Pennsylvania.

*The graphs below illustrate the fade resistance of the new Armstrong friction materials. In dynamometer tests at the Armstrong Research and Development Center, a single clutch plate (7½" O.D., 6¼" I.D., faced both sides) is engaged and disengaged thousands of times, each time absorbing the 28,000 foot-pounds of kinetic energy which the machine develops at 1,000 rpm. During each engagement, torque curves similar to the one at the left are recorded. The three factors noted on the torque curves are plotted to form "fade" curves, shown on the graph at right.*



Torque curves (left) are graphically recorded to show the characteristics of each engagement of the dynamometer. The engagement begins at the right-hand part of the curve. Torque builds up rapidly until the closing pressure reaches its full value at the point marked *minimum coefficient of friction*. The flywheel decreases in speed as the curve proceeds to the left, *maximum coefficient of friction* occurring as it is brought to a halt. *Stopping time* is then noted for that engagement.

The fade curves above indicate to what extent these three factors varied during tests of the new Armstrong FM-45 material covering 7,500 engagements. Note that the curves are practically horizontal, showing that performance characteristics are virtually unchanged after this prolonged torture test.

**Armstrong RESILIENT FRICTION MATERIALS**

... used wherever performance counts

# New twist in testing ...a torsional exciter

**T**ORSIONAL testing has been done with rectilinear motion shakers by applying ingenuity in linking table to specimen. But here's a new MB exciter that produces torque *directly*. Its performance characteristics permit you to use it as a *calibrator* for torsional pickups and accelerometers . . . as well as for testing gyros and relays (as examples), or checking torsional vibrations of armatures, or determining torsional modes in various rotating parts.

## OPERATING FACTS

At free-table, no load, this MB Model CA 1050 Exciter oscillates at up to 1600 cps without resonance in moving elements. It develops 110 ft. lbs torque, which produces angular accelerations as high as 1570 radians/

sec/sec. Maximum total displacement is 45°.

## A MATCHED SYSTEM

Any one of several MB electronic power supplies drives the equipment, depending on the specific frequency range, power, and performance you want. The MB Model T51 Power Supply shown comes with automatic cycling controls if desired.

## SEND FOR DETAILS

Technical data available. And for more information on how and where to use this unusual equipment, contact our staff of vibration specialists. You can't come to a better qualified authority on the subject . . . nor to one more willing to help on your specific vibration testing problems.

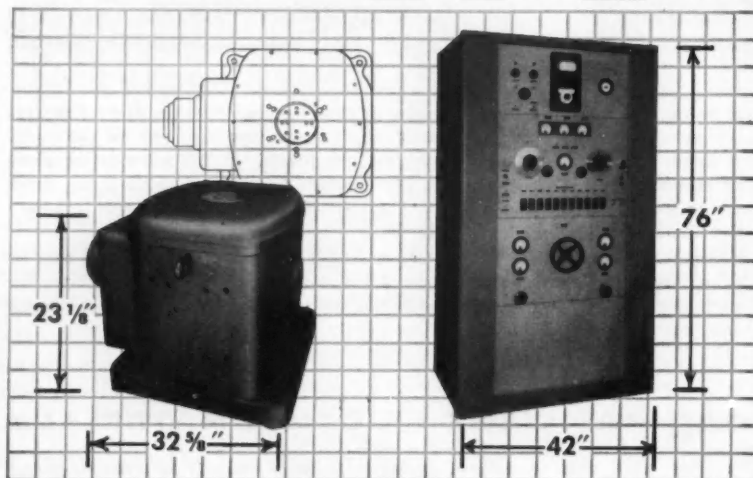


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## About SAE Members

Continued on page 108



Dickerson

MacLean

**JULIAN D. DICKERSON**, formerly staff assistant to vice-president—operations, Crucible Steel Co. of America, has been named to the newly-created position of manager—steel production for the company. Dickerson joined Crucible in 1953 as chief metallurgist at Midland Works, and was transferred to the Pittsburgh headquarters in 1955 as staff assistant.

**J. ALLAN MACLEAN** has been named assistant group executive of the Bendix Aviation Corp. In this post, MacLean will head the Bendix Products, Hamilton, and Lakeshore Divisions of the company. He joined the company in 1940 and has served as aircraft products engineer, quality manager, director of industrial relations, and general manager of the automotive products section.

**KLAUS C. KARDE** has been appointed to the newly established position of director of engineering, research and development, Miehle - Dexter Supercharger Division, Miehle-Goss-Dexter, Inc. Prior to his new post, Karde was manager of research and development, P & H Division, Har-nischfeger Corp.



Wrobbel

Stoessel

**RAYMOND J. WROBBEL** has become product manager of the Garlock Packing Co.'s Klokure Oil Seal line. Formerly Wrobbel served as sales engineer, Chicago Rawhide Mfg. Co.

**ROBERT F. STOESEL** has been named to the newly-created position of Hercules commercial sales manager, Georgia Division, Lockheed Aircraft Corp. He formerly served as manager of sales engineering for the company's Georgia Division. Stoessel has been with the company for 14 years.

# IN ENGINEERING, THE BEST OPPORTUNITIES ARE IN AVIATION

# IN AVIATION, THE BEST OPPORTUNITIES ARE AT TEMCO

## STRUCTURES ANALYSIS ENGINEERS

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## DYNAMICS ENGINEERS

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as Supervisory positions are available for qualified Dynamic Analysis and Dynamic Methods Engineers. Included are assignments in such areas as Theoretical Flutter Analysis, Supersonic Oscillating Aerodynamic Theory, Vibration Theory and Thermal Effects of Structures.

## ELECTRONICS DESIGN ENGINEERS

Missile and aircraft prime contracts require extensive expansion of our electronics systems design and

analysis sections. Experience preferred in transistor applications, pulse and video circuits, servomechanisms, general circuit design, guidance and radar systems analysis, audio circuits, electro-optical transducers, microwave components design, radome design and antenna design.

## EXPERIMENTAL LABORATORY ENGINEERS

High-temperature structures, environmental, servo, hydraulics, and instrumentation groups are but a few of the laboratory areas offering interesting and rewarding assignments on both missile and airframe prime programs. Senior Engineers and Engineer positions open.



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MR. JOE RUSSELL, Engineering Personnel  
Dep't 170-E, Room 10, Temco Aircraft Corp.,  
Box 6191, Dallas, Texas

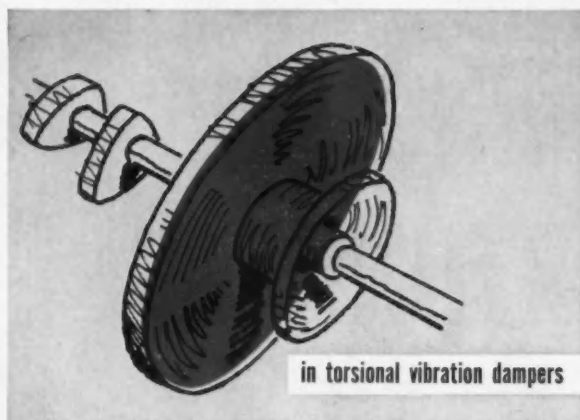
Please send me complete details of the Temco story of unusual opportunities for creative engineers. I am especially interested in

NAME \_\_\_\_\_

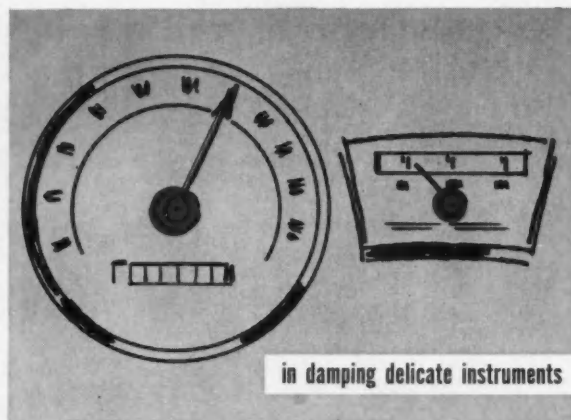
ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_

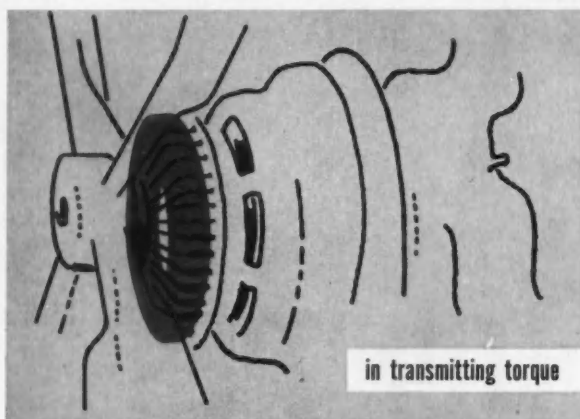
STATE \_\_\_\_\_



in torsional vibration dampers



in damping delicate instruments



in transmitting torque



in liquid springs

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## Briefs of SAE PAPERS

Continued from page 6

peller or drive shafts to help attain car of lower silhouette; instruments used in study of causes of vibration referred to as high speed roughness, experienced in some 1956 Buick cars; offset between two shafts as it affects degree of vibration created by cardan type of universal joint; test results.

**Passenger Ride and Comfort Measurements as Seen by Manufacturer, J. J. McDONALD. Paper No. 139.** Presented June, 1957, 4 p. Why normal test methods are not applicable to solution of problems involving passenger ride and comfort measurements; in particular, absence of definite design criteria, due to physiological and psychological aspects involved and deviation of particular individual from hypothetical average.

**Factors Affecting Fuel Economy (MPG), J. C. MILLER. Paper No. 142.** Presented June, 1957, 11 p. Study conducted by Cummins Engine Co. under actual operating conditions; extensive instrumentation was installed on typical tractor-trailer so that accurate data could be obtained; at maximum engine speed, fuel economy is low; in 35 to 50 mph range, each increase of one mph in cruise speed decreases economy by roughly 1/10 mi per gal.

**Autoignition Associated with Hot Starting, F. W. BOWDITCH, R. F. STEBAR. Paper No. 147.** Presented June, 1957, 23 p. Causes of high torque requirement in starting hot gasoline engines; analysis of results of flame photographs taken of combustion process; investigation of effect of engine operating variables on autoignition phenomena associated with hot starting.

**New Small Military Standard Engines, L. D. BAKKE, R. F. DENNIS. Paper No. 149.** Presented June, 1957, 29 p. Basic specifications of family of six aircooled gasoline industrial type engines in 3-cyl bore sizes of 4-cycle type, ranging from 1/2 to 20 net continuous hp, being jointly developed by U. S. Army Engineer Research and Development Laboratories and Continental Motors Corp.; Model 1A08 1 1/2-hp engine, exemplifying features incorporated in new engines, is discussed in detail; performance; tables; illustrations.

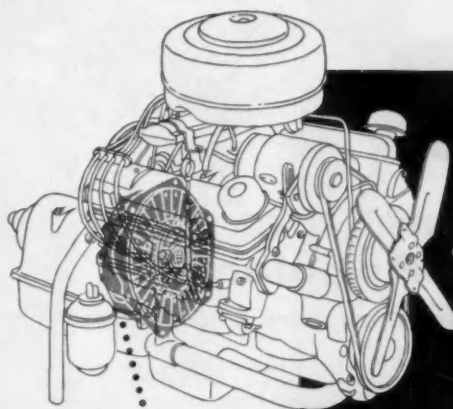
**European Developments in Small Aircooled Engines, W. E. MEYER.**

**Paper No. 148.** Presented June, 1957, 22 p. General characteristics of high speed engines of up to 10 hp for industrial application; typical and unusual designs and differences between European and American engines; development of small high speed diesels ranging from 6 hp up to 4 and 2-cycle type; description of some designs; details of components and accessories.

**Free-Piston Tractor Power Plant, O. B. NOREN, R. L. ERWIN. Paper No. 150.** Presented June 1957, 14 p.

Program at Ford Motor Co. to obtain basic thermodynamic and design information on small high speed engines as basis for industrial or automotive power plant; performance design calculations established basic geometry of 519 engine; energy equations; mechanical design of valve, fuel injection and starting system; state of development reaching 80% of its design point power provides foundation for commercial development; application to Typhoon tractor.

Continued on page 116



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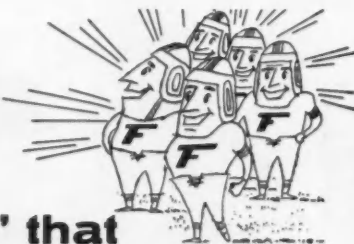
Chicago 38, Illinois

## Briefs of SAE PAPERS

Continued from page 115  
Aspects of Automotive Gas Turbine  
for Military and Commercial Vehicles,

W. A. TURUNEN, R. SCHILLING, E. L. BAUGH. Paper No. 151. Presented June, 1957, 12 p. Predictions on place of gas turbine engine based on actual experience with tests in vehicles ranging from light weight high speed car, 230 mph Firebird I, to heavy duty commercial truck, GCW Chevrolet Turbo-Titan; details of test vehicles; performance; fuel economy; durability tests; future commercial truck and bus requirements; general and military applications; manufacturing costs.

Future of Diesel Engine in Commercial Vehicles, B. UCKO. Paper No. 152. Presented June, 1957, 7 p. Conventional 4-stroke cycle diesel engines evaluated; graphs of performance characteristics, volumetric efficiency, economy level characteristics of naturally aspirated 672-cu. in. diesel; increased output and economy level characteristics of same engine mildly turbocharged; goals which must be realized and how to obtain them.



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Air-cooled Diesel Engine—Advantages and Applications, F. W. LOHMANN. Paper No. 153. Presented Aug., 1957, 16 p. Development of internal combustion engines of dual combustion cycle type and gas turbine; development program at Kloeckner-Humboldt-Deutz AG, Germany, resulted in standardized family of high speed air cooled 4-stroke 1-, 2-, 3-, 4-, and 6-cyl vertical in-line engines, and V-6, 8-, and 12-cyl engines with unit cylinder type of construction; operating advantages; versatility of engines in oil field operations.

Friction Brake Limitations in Logging Truck Service, H. N. ARD. Paper No. 156. Presented Aug., 1957, 11 p. Study of operating conditions encountered by trucks which tax drum type friction brakes beyond their capabilities; trucks of 100,000 GVW class with 150-hp diesel engine 10 ft bunks, 11:00×20 tires and 17¼×5½ brakes, and trailers having 16½×6 in. brakes were used; major factor limiting ultimate capabilities in absence of adequate brake cooling system; other factors; graphs and curves.

Efficiency and Simplicity in Off-Highway Transmission, T. BACKUS, C. M. PERKINS. Paper No. 157. Presented Aug., 1957, 10 p. Peak efficiency required to take full advantage of dirt moving equipment such as Euclid, Tournapull and Dart trucks is best supplied by simple geared transmission unimpaired by losses inherent in fluid drives; design details of Fuller transmission, combined with 2-speed auxiliary; control system; torque multiplication; speed comparison diagram.

Automatic Transmissions in Heavy Duty Trucks, R. M. SCHAEFFER. Paper No. 158. Presented Aug., 1957, 14 p. Influence of hydraulic drives in off-highway applications on evolution of automatic transmissions and development of various types and makes for light, medium and heavy duty trucks; design and development objectives of Chevrolet's 6-speed Powermatic transmission in three forward ranges for medium and heavy trucks; cost per ton mile; typical applications; operating experience with Hydra-Matic and Powermatic.

Continued on page 118

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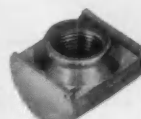
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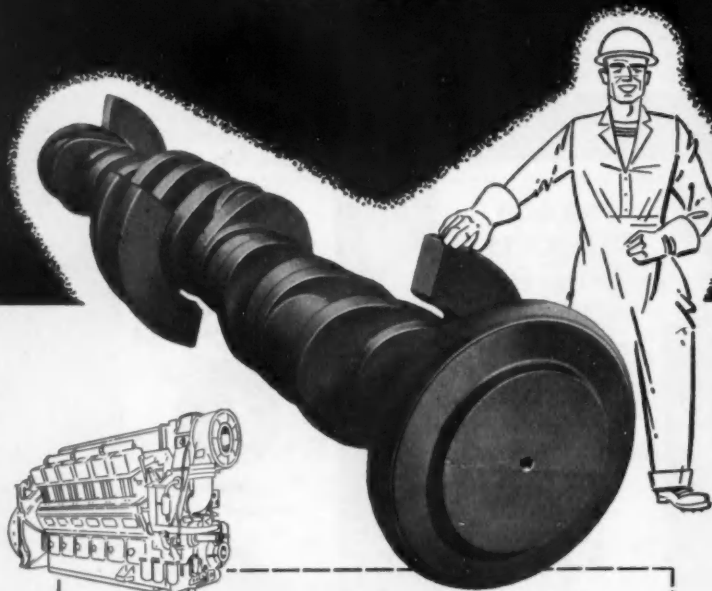
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## Briefs of SAE PAPERS

Continued from page 116

**LTL Trailer, H. A. DOZIER. Paper No. 164.** Presented Aug., 1957, 9 p. Account is based on experience at Consolidated Freightways, Inc., dealing with problem of designing LTL (less than trailer load) trailer; accounting aspects of equipment design; general specifications, floor design and materials used, problem of air circulation and best solutions; false wall design; minimum insulated trailer, and frame structures.

**Development and Operational Problems of Heavy Duty Logging Trailers, H. A. PUXON. Paper No. 165.** Presented Aug., 1957, 4 p. Approach taken at Columbia Trailer Co., Ltd., in designing logging trailer of off-highway type with minimum of moving and wearing parts; details of components.

**Trailer Suspensions, R. G. FLAGAN. Paper No. 166.** Presented Aug., 1957, 11 p. Suspension design as related to highway cargo trailers, maximum legal loads in various states being design criteria; problems which must be met and solved; various configurations of leaf spring suspension, steel torsion and rubber spring, and air suspension which appears to be gaining increased utilization.

**Air Cleaners—The Why of Wet or Dry, H. M. TURNER. Paper No. 167.** Presented Aug., 1957, 13 p. Factors influencing choice of type of cleaners for tractors and earthmoving vehicles; need of varied performance; review of type and relative performance prior to and since 1950; paper cartridge air cleaners, and their use as secondary filters; analysis of field operation of oil bath and dry type air cleaners factors contributing to oil carry over; design factors; laboratory performance of three designs of dry type compared to standard oil washed unit.

**Integrator for Determining Total Emission of Automotive Exhaust Gas Components, R. T. VanDERVEER, J. D. JENKS, R. L. DENNIS. Paper No. 169.** Presented Aug., 1957, 16 p. Quantizing Voltage Integrator system of totalizing hydrocarbon emission from automobile during operation involves use of multiplying potentiometers to obtain product of cubic feet per min of exhaust and exhaust hydrocarbon concentration; product is integrated electronically and totalized during operation as accumulated weight of hydrocarbons emitted; principle of oper-

Continued on page 120

SAE JOURNAL, NOVEMBER, 1957



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## Briefs of SAE PAPERS

Continued from page 118

ation and counter circuit; schematic diagram.

**Automotive Exhaust Hydrocarbon Reduction During Deceleration by Induction System Devices, H. H. DIETRICH et al. Paper No. 170.** Presented Aug., 1957, 33 p. Progress report of work performed to date by Induction System Task Group, formed by AMA to develop and evaluate automotive induction system devices for reduction of unburned hydrocarbons; goals and methods of measurement; devices; carburetor throttle controls; idle fuel shutoff devices; ignition cut-off burner; additional devices.

**Los Angeles Traffic Pattern Survey, D. M. TEAGUE et al. Paper No. 171.** Presented Aug., 1957, 53 p. Report by Traffic Survey Panel of AMA describing operating conditions under which automobiles are driven in Los Angeles traffic; instrumented cars were used to show variations in speed, manifold vacuum, and other pertinent data; most significant of major variables affecting car operation include individual driving habits; transmission type; routes and traffic densities; car and engine performance characteristics; recommended driving cycles based on results.

**How to Recognize Unnecessary Vehicle Exhaust Smoke Emissions, F. W. BOWDITCH et al. Paper No. 172.** Presented Aug., 1957, 4 p. Program of Special Group on Exhaust Smoke of AMA consisting of engineering groups from automobile, truck and engine manufacturers and work achieved in cooperation with Detroit Smoke Abatement Bureau and Police Department; new exhaust smoke ordinance Apr. 10, 1956; training film presenting problem to enforcement personnel; pocket guide to identify vehicles that are smoking unnecessarily

**Automobile Exhaust Gas Treatment—Industry Report, G. L. NEDEL et al. Paper No. 173.** Presented Aug., 1957, 11 p. Work achieved by Exhaust System Task Group formed by AMA to study methods of removing hydrocarbons from automobile exhaust gases, limited to treatment of exhaust after discharge from engine; conclusion arrived at is similar to that reached by Air Pollution Foundation: most practical way is by oxidation; development and evaluation of oxidation devices, both catalytic converters and after-burners; engineering problems.

Continued on page 123



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Continued from page 120

**Single Cylinder Engine Tests of Oxidation Catalysts, W. A. CANNON, E. F. HILL, C. E. WELLING. Paper No. 174.** Presented Aug., 1957, 8 p. Preliminary evaluation of catalytic method for treating exhaust gas and requirements which such catalyst must fulfill; table of catalysts selected for testing with single cylinder Lauson Model H-2 engine; test procedure and results with nonleaded and leaded fuels.

**Development of Test Procedure for Measurement of Carbon Monoxide in Automobile Passenger Compartments, D. G. FOWLER et al. Paper No. 175.** Presented Aug., 1957, 4 p. Procedure outlined by Special Group on Carbon Monoxide of AMA as minimum test for assessing contamination of vehicle by its own exhaust gases; suggestions made refer to Instrumentation recommended; test conditions under which adequate number of readings should be taken; information to be recorded.

**What Modern Earthmoving Machinery Has Done to Control Costs, H. A. RADZIKOWSKI. Paper No. 176.** Presented Sept., 1957, 12 p. Effect of constant increase in equipment productivity on highway construction costs, labor usage and highway maintenance costs is illustrated by graphs and tabulation; highway maintenance costs vs vehicle mile; estimates of grading costs to eliminate deficiencies on all highway systems by 1984, compiled by U. S. Bureau of Public Roads; some of design standards of 41,000-mi Interstate system are discussed.

**Torque Converter in Shovels, Draglines, Cranes, F. J. STERNAD. Paper No. 177.** Presented Sept., 1957, 12 p. Basic machinery and component functions in typical shovel crane with conventional direct engine drive are explained as background for factors which engineer must consider in applying converters such as desirable performance curves, output shaft governors, and heat dissipation; low inertia engine flywheels to permit rapid engine acceleration; provision of positive disconnect clutch; training of operators; advantages and future trends.

**St. Lawrence Project, L. W. OLMSTEAD. Paper No. 178.** Presented Sept., 1957, 7 p. Construction experiences encountered, methods and equipment used by Seaway and Power entities during 1956 to excavate U. S. portion of Seaway, 10-mi Long Sault

Canal near Massena, N. Y.; discussion of some outstanding features such as vertical lift gate and highway tunnel of Eisenhower Lock; system of dikes; power features and enumeration of participating construction agencies; Long Sault Power dam and High Level Bridge.

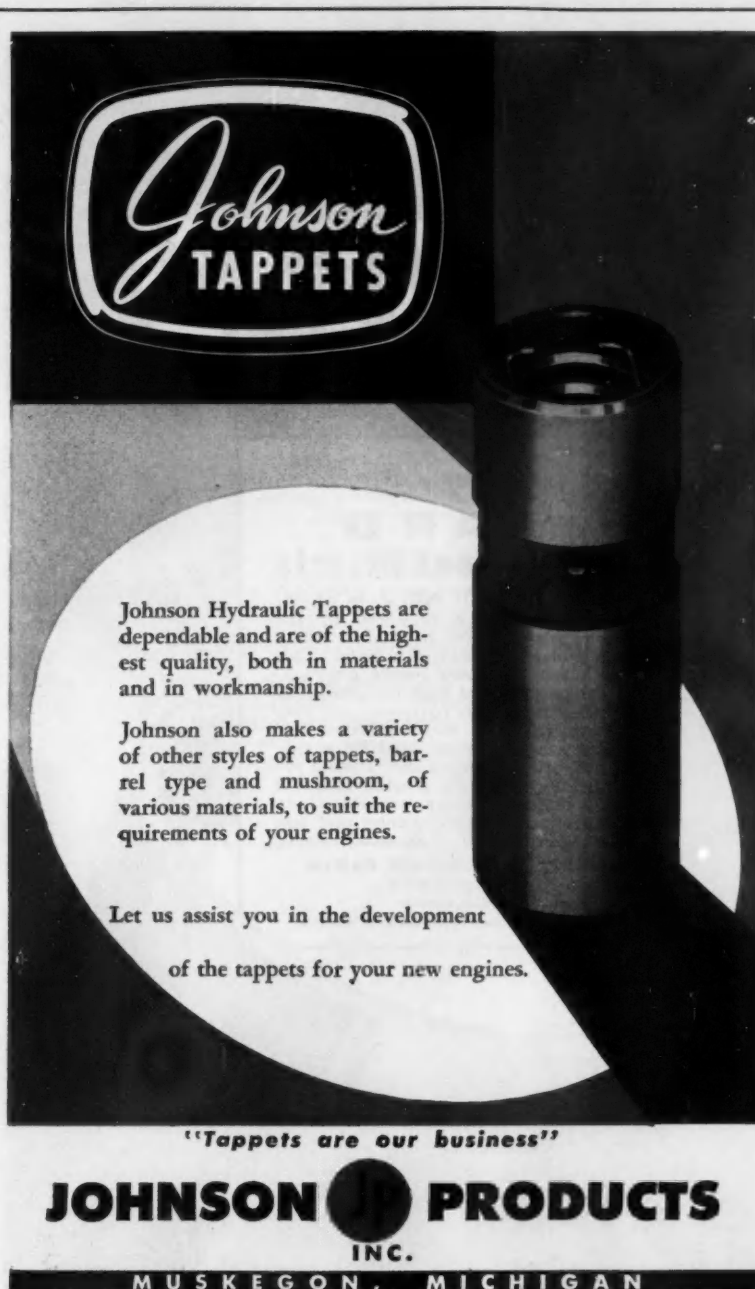
**Legal and Technical Aspects of Over-The-Road Movement of Heavy Pneumatic Tired Cranes, Q. J. WINSOR. Paper No. 179.** Presented Sept., 1957, 13 p. Summary of existing conditions for moving cranes on highways and

existing standards specifying maximum weights or widths permitted by state Laws or regulations; two conditions of moving heavy pneumatic tired cranes, namely, legal vehicle and permit vehicle are discussed; chart listing legal conditions in all states for extreme axle spacing from 9 to 21 ft.

### MATERIALS

**What Happens to Automotive Materials on Test Track or Proving Ground—King Sized Material Testing Ma-**

Continued on page 124



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## Briefs of SAE PAPERS

Continued from page 123

chine, R. W. GAINES, W. A. McCONNELL. Paper No. 128. Presented June 1957, 10 p. Purpose of durability testing operations at Ford's Proving Ground, Romeo, Mich., is to subject

newly designed vehicle to same type of service as roughest customer will give it; general geometry of durability road and pattern of chuck holes, permanent chatter bumps, waves and frost heaves, etc; layout of proving ground.

**Recent Developments in Accelerated Testing of Plated Coatings, W. L. PINNER, R. B. SALTONSTALL. Paper No. 132.** Presented June 1957, 6 p. Review of work carried out by Research Project No. 15, American Electroplaters' Soc to create dependable accelerated corrosion test for decorative plated coatings; two accelerated test proce-

dures which appear destined to constitute successful conclusion: acetic acid modification of salt spray test, and Corrodokote test; procedure and formula.

**Accelerated Tests for Anodic Films, R. S. DALRYMPLE. Paper No. 133.** Presented June 1957, 5 p. Accelerated tests cannot take place of long term studies and must be followed up with environmental studies; some current accelerated tests employed to evaluate anodized aluminum are examined: two salt spray tests: ASTM-B287-54T, and ASTM-B-117-54T; fadometer tests; weatherometer studies; techniques and devices employed in physical tests to evaluate abrasion resistance, hardness and thickness of anodic films.

### PRODUCTION

**Effect of Vacuum Melting on Bearing Steels, L. D. COBB. Paper No. 71A.** Presented Mar., 1957, 3 p. Based on New Departure Laboratory endurance test results progress made in increasing ball bearing capacity from 1918 to 1956 is shown; bearings were made of air melted 52100-51100 steel rings and balls by air melting practice; results of tests undertaken to improve bearing performance by use of vacuum melting practices; contamination problem.

**Effect of Vacuum Melting on Low Alloy Steels, A. M. AKSOY. Paper No. 71B.** Presented Mar., 1957, 7 p. Improvements obtained in mechanical properties of low alloy steels for aircraft designs as result of vacuum melting are described; tensile, impact and fatigue properties of vacuum melted 4340 and UHS 260 steels are given and compared with those of air melted material.

**New Ways of Shaping Metal, C. L. SPORCK, W. H. BUSCH. Paper No. 131.** Presented June 1957, 11 p. "Floturn Method", developed by Lodge & Shipley Co., utilizes cold rolling techniques performed in steel mills, however, metal is displaced parallel to center line of part being formed; basic difference between spinning or drawing is that metal is obtained from thickness of blank and not from diameter; photomicrographs showing effect on physical properties of material; possible application in automotive field.

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Readers Information Service" blank on page 5 corresponding to the numbers appearing after the titles of the digests of interest to you.

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To Order Paper No. 217 . . .

on which this article is based, see p. 5



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## BASIC SPECIFICATIONS FOR AIRESEARCH TURBOCHARGERS

MODEL	F-51	C-60	A-60	E-100	B-100
Output—lb/min. (Standard Conditions)	29-51	30-60	38-60	50-100	60-100
Diameter—in. nom.	10.0	11.5	15.25	15.1	15.4
Length—in.	10.5	12.9	16.75	14.7	17.1
Weight—lb.	40.0	95.0	125.0	112.0	135.0



**AiResearch Industrial Division**

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS

## New Members Qualified

These applicants qualified for admission to the Society between Sept. 10, 1957 and Oct. 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

### Alberta Group

William N. Csokonay (A), Raymond R. Gregory (A).

### Baltimore Section

George M. Bunker (M), Albert W. Foreman (A), Gilbert Wilkes, III (M).

### British Columbia Section

Ernest Scott (A).

### Buffalo Section

Vaughn H. Hardy (M), John Gerard Hart (M), John Noble MacKendrick (M), Ivan W. Miller (A), Myron Allan Seiden (J), Alfred J. Taylor (J).

### Canadian Section

J. A. Carruthers (A), H. B. Dunthorne (M), William Henry (M).

### Central Illinois Section

Charles F. Boren (J), Russell O. deCastongreene, Jr. (J), William R. Griffith (A), Tracy W. Peck (M), Richard R. Smith (J), Edward William Snell (M).

### Chicago Section

Louis E. Benton (A), Frank M. Guinn (A), William T. Harrison (M), James Bernard Kearney (A), Ernest J. Leidberg (A), Elden LeRoy Mathias Lippo (J), Kenneth J. Nicholson (J), Gustaf H. Olson (M), Merle W. Paquette (M), Thomas W. Perry (M), Robert Edmund Reichard (J), Robert M. Riley (J), Harry Daniel Robb (M), Michael M. Woelfel (J).

### Cincinnati Section

John W. Bergman (M), Emil L. Eckstein (M), Lloyd L. Gardner (J), Morris R. Lynn (M), John B. Montgomery (M), Clyde K. Turley (M).

### Cleveland Section

Robert E. Alexander (M), Manuel F. da Silva De Medeiros (A), T. R. Fredriks (M), Robert E. Hughes (M), James Carl Keebler (M), Frank A. Kender (A), W. F. Klein (M), M. H. MacKusick (M), Norman J. Musil (A), Robert K. Nelson (M), Fred B. Schneider (M), James L. Strong, Jr. (M), Clark I. "Bud" Witwer (A).

### Colorado Group

Peter John Konesky (J).

### Dayton Section

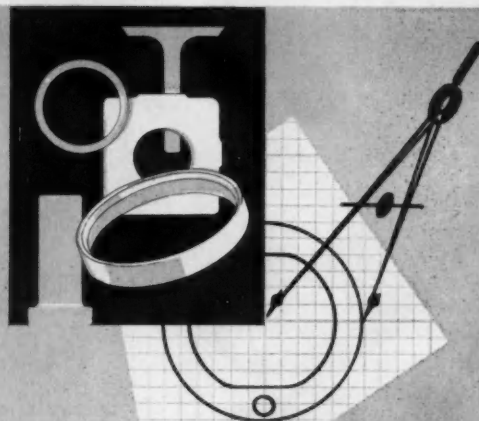
Larry D. Creeger (J), Maurice S. Decker, Jr. (M), Robert J. Kick (M), Kermit D. Kuhl (J), Ernest Ray Ruthertford (A), Richard G. Schumann (M), Robert E. Teeghman (M).

### Detroit Section

Robert Sumner Anderson (J), Eugene Ash (J), Charles Robert Aumann (J), John C. Basiletti (M), Ralph W. Bishop (J), John F. Boyle (J), Edw. E. Bozyk (M), William Breuer (A), Earl

F. Burton (M), William R. Callow (M), A. J. Carter (M), Arthur Causley (A), John W. Compton (M), Arthur E. Cook (M), David H. Davies (M), John B. Demchak (M), Robert F. Diederich (M), Lawrence J. Dranchak (J), Richard J. Dunklau (J), Richard K. Eshelman (M), Earl Karlton Fake (J), Dudley F. Fiscus (M), Arthur Alexander Folgart (M), Robert K. Frank (M), George F. Gerbstadt (M), Paul A. Gionet (M), Eugene K. Groves (M), Donald W. Hamilton (J), William B.

Continued on page 130



## • C A S T I N G S

### "TECHNICAL POLICEMEN"

on patrol  
every hour, every heat, every day

If you require *meticulous* precision in the metallurgical, chemical, and physical properties of your castings, you will find it here.

Customers tell us that our ability to maintain the most complex alloy specifications is so marked that we are often referred to as "the prescription counter foundry."

We specialize in small castings in high volume—alloyed gray and white irons, and high alloy steels. We invite inquiry.

Makers of important component castings for the automotive, aircraft, hydraulic, and special machine tool industries.

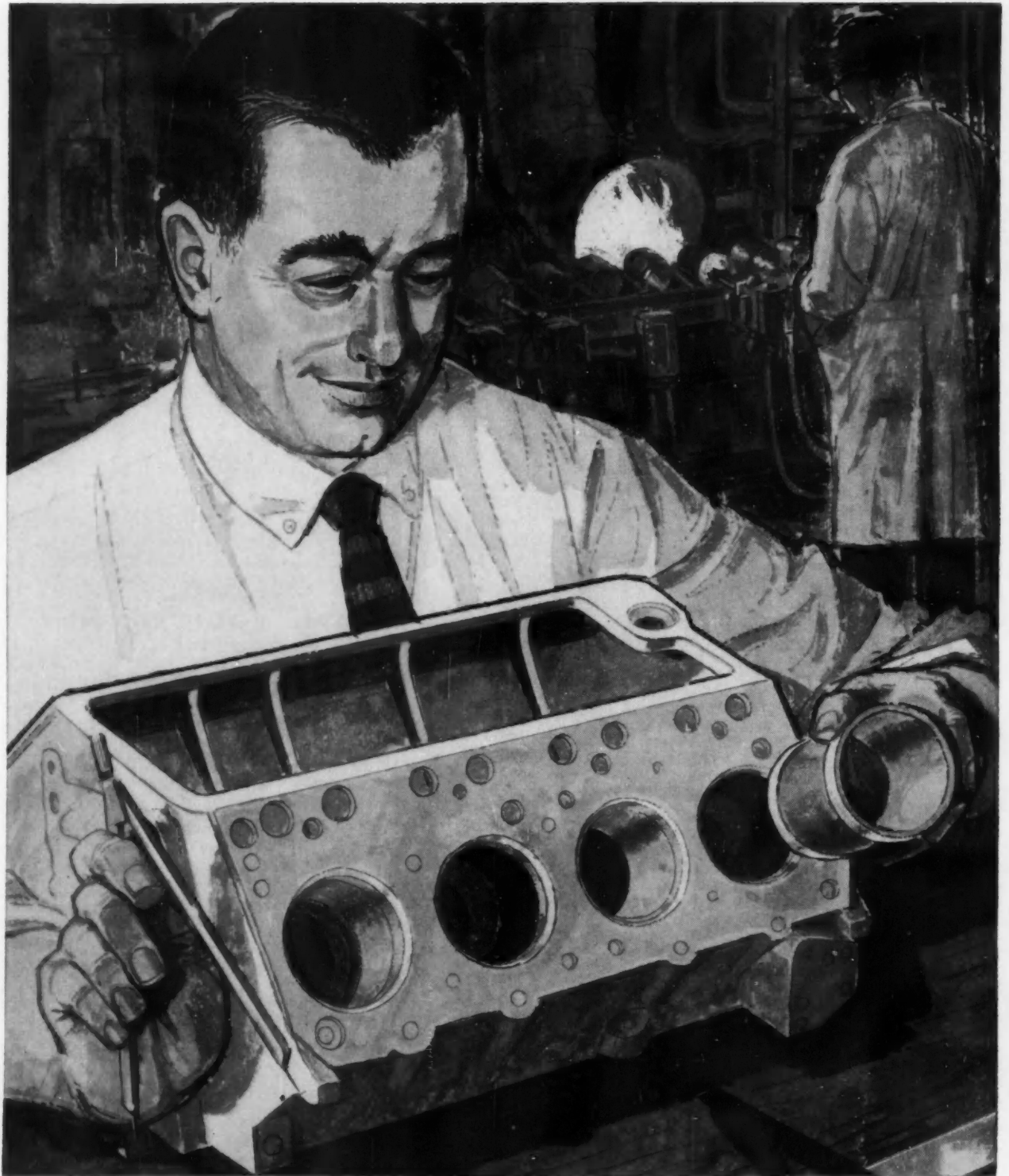
ENGINEERING CASTINGS, INC.

Marshall, Michigan

Licensed Producers of Ni-Hard, Ni-Resist, Ductile Iron, Ductile Ni-Resist



# On drawing boards now...



# the all-aluminum engine!

Out of the Alcoa Development Division's Laboratory have come new processes that have leading manufacturers designing all-aluminum engines right now. After more than a decade of experimentation with sprayed cylinder liners, a method has been developed that gives aluminum a wear resistance superior to that of iron.

## Hard coating only 3/1000 inch thick

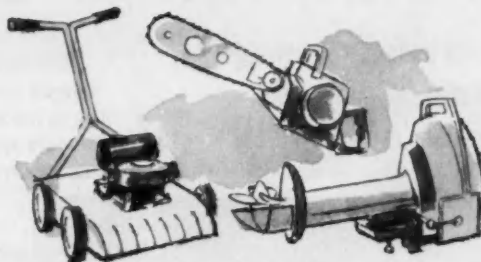
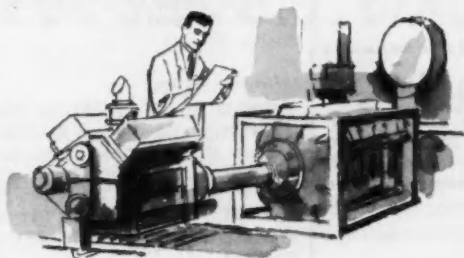
A hard coating of molybdenum is sprayed on the aluminum, using the patented Metco "Sprabond" process. Coating thicknesses ranging upward from 3/1000 are common. A coating of steel may be sprayed on the molybdenum if desired.

## Cylinder liners investigated

Considerable development is centered around the use of liners in an aluminum block. The die-cast or permanent mold-cast method may be used to manufacture blocks, eliminating the necessity of using a sand core. Some designers favor using an iron liner. Other engineers prefer the use of an aluminum liner sprayed with molybdenum. One engineering group is investigating the use of hard aluminum alloys—rings would bear directly on aluminum!

## Many benefits

The all-aluminum automotive engine deserves a new design from top to bottom to obtain all the benefits inherent in aluminum. Better temperature distribution contributes to greater freedom from thermal distortion. Important among the benefits, of course, is weight saving.



The much lighter aluminum engine will improve weight distribution in the vehicle tremendously, adding to roadability and ease of handling.

## Smaller engines ready for production

Builders of industrial engines for chain saws and lawn mowers and outboard engines, already producing aluminum engines, are investigating this sprayed coating. Experimental engines have logged many hundreds of hours accumulating favorable cylinder wear data. The hard-faced molybdenum coating that is used does the job with wear to spare.

## Other applications


Other likely applications for the Sprabond process include "ways" for machine tools, V-belt pulleys, brake drums, cylinder walls on hydraulic fixtures, pumps, compressors and clutch plates. Now that aluminum can be given wear resistance superior to that of iron, one of the last barriers to its use in many new applications is removed.

## Let Alcoa help

Alcoa, the most experienced producer of aluminum in the industry, stands ready to offer the facilities of its laboratories and the knowledge of its engineers to manufacturers developing all-aluminum engines. Let us work with you. Write Aluminum Company of America, Development Division, 1844-L Alcoa Building, Pittsburgh 19, Pennsylvania.



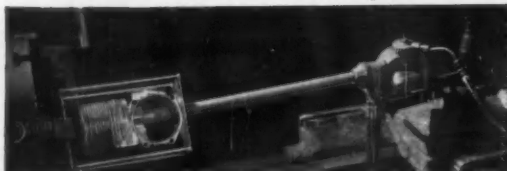
**NEW! "ALCOA THEATRE"**  
Exciting Adventure, Alternate Monday Evenings

**ALCOA**  **ALUMINUM** gives every car more **GLEAM AND GO**

This is the process that made possible the new aluminum engine described in the ALCOA ad on page 128, 129

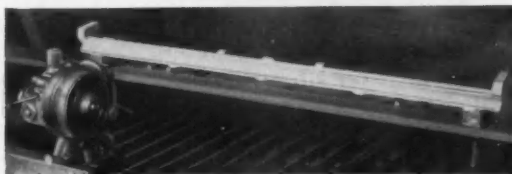
It works because lightweight, hard-faced aluminum and magnesium outwear steel

Molybdenum, steel or stainless sprayed coatings, applied at high speed and low cost, offer many opportunities for product improvement.



Inside cylinder wall of portable gasoline engine being sprayed with molybdenum. Part showed little or no wear after 4,000-hour test run. Chrome-plating broke down in less than 400 hours.

Aluminum torque tube, used in control of aircraft trim tabs, being hard-surfaced at end bearing sections. Molybdenum is used on these press-fit bearing sections and build up to required dimension completed with hard stainless steel.



This accounting-machine undercarriage—made of aluminum for light weight—is being hard-surfaced by metallizing with steel.

A wide range of hard metals, including molybdenum and hard stainless steel are being applied to light weight metals to provide even longer service life than is possible with solid steels, yet retaining the weight-saving advantages.

Application is relatively simple—fast, modern metallizing guns will spray over 20 pounds of stainless steel per hour. This, in the comparatively thin coatings used, usually ranging from

.003" to .010", spells high-speed surface coverage. Semi-automatic control equipment is available for production line operations. Free operator training and on-the-spot service is supplied by full-time, company-trained, field engineers.

For further information send off the coupon attached or even better, write, giving us some idea of the application you have in mind.



## Metallizing Engineering Co., Inc.

1193 Prospect Ave., Westbury, L. I., New York • cable: METCO  
In Great Britain: Telephone: EDGEWOOD 4-1300  
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

Please have a field engineer call upon me.

NAME	_____
TITLE	_____
COMPANY	_____
ADDRESS	_____
CITY	_____
STATE	_____

## New Members Qualified

continued

Heaton (J), Warren Deem Hirschfield (J), George F. Hodgson (M), Theodore Sommerville Jentsch, Jr. (A), Henry Albert Jewell (A), Paul R. Kelps (J), Everett P. Kennedy (M), Ronald S. N. Lee (J), Floyd B. Lux (M), Algerdan Malzer (M), Ian R. Olley (J), George Pettipren, Jr. (A), Laurence M. Phillips (M), John F. Randall (M), Fred G. Seaver (M), Charles F. Sporman (M), Richard E. Stover (J), Fred H. Watson (M), Malcolm Edward White (J), John C. Witwer (M), Oreste John Zamparo (J).

### Indiana Section

Merle Dalton Coy (M), John Eugene Hodel (J), John Saxon Ivey (J), Victor W. Peterson (M), Leland L. Reich (J), Theodore A. Spanke (M), Frank B. Steward (M), Eugene Charles Suding (J).

### Kansas City Section

2nd Lt. Richard Lea Humphrey (J), James R. MacPherson (M).

### Metropolitan Section

Dallas W. Breeden (J), George V. Cambeis, Jr. (M), William Clark (A), Robert A. Cowie (J), Frank M. Emmans (J), Michael Henry Farmer (M), Richard C. Gazley, Jr. (J), William T. Haupt (A), Harvey A. Hedlund (J), Martin L. Kapin (M), Richard A. Katzman (J), Aaron J. Keeperman (M), Henry Martin (J), Carl W. Schonfeld (M), B. A. Stransky (M).

### Mid-Continent Section

Robert A. Lauducci (M), Daryl Frederick Southard (J).

### Mid-Michigan Section

Jess C. Barrow (M), Joseph N. Goulish (J), Roderick W. Kallgren (J), Mohamad Mounir Kamal (J), Thomas J. Krieg (M), Donald L. Massy (J), Carroll C. Seelye (M), Lawrence B. Socha (J).

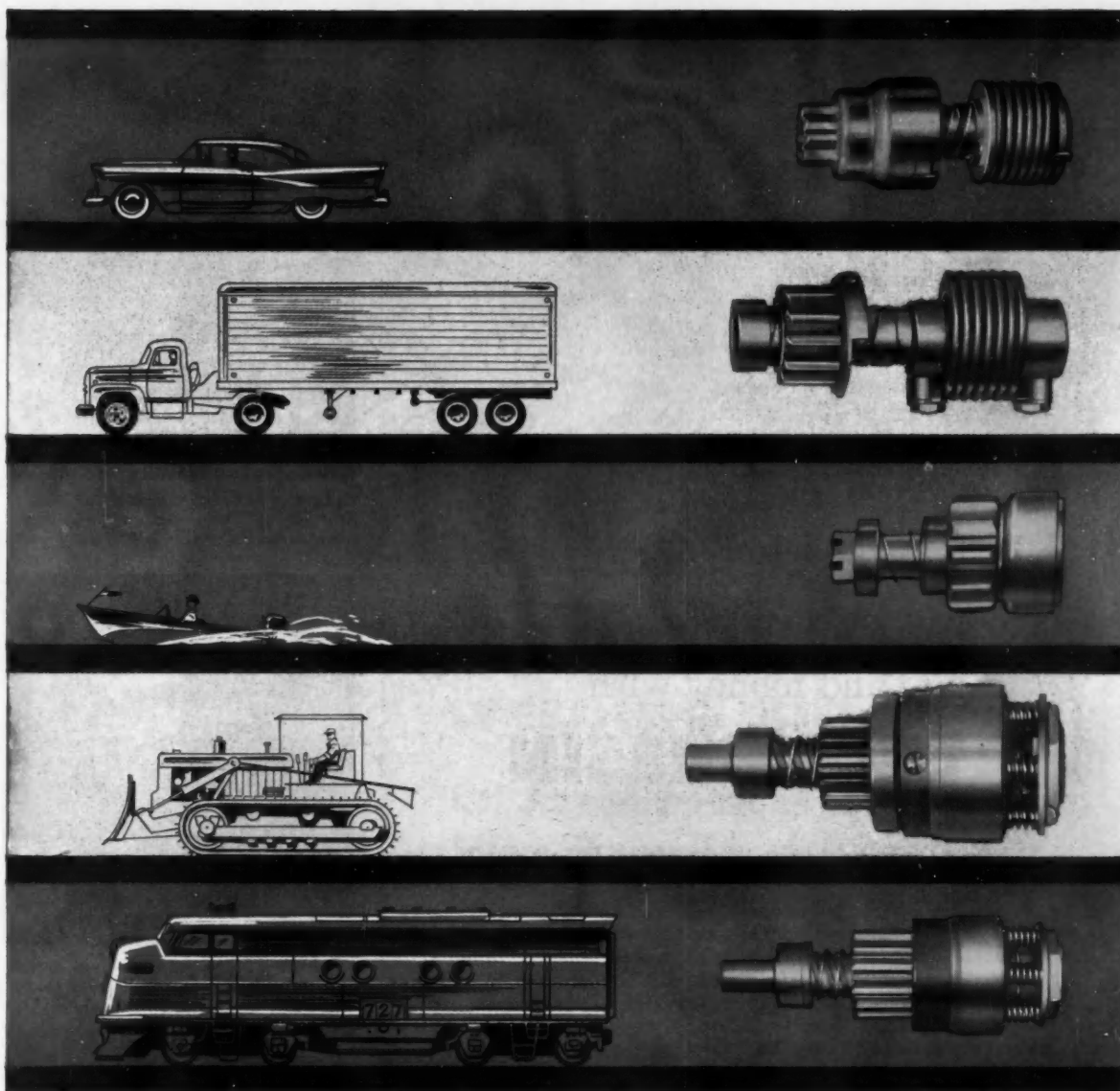
### Milwaukee Section

Walter Clarke Arnold (M), Russell C. Atterberry (M), Roy R. Buck (M), Wayne E. Hartman (M), Alfred W. Hubbell (J), Don F. Kueny (J), Norbert F. Mullaney (M), Boyd S. Oberlink (M), Stephen John Perpich (M), Richard James Radwill (M), John S. Randall (M).

### Montreal Section

Leopold K. Arnold (A), R. Boyd Ferris (M), Stephan Gyurik (M), Zoltan Peter Kekes (M), William George Park Merrifield (M), George H. Schilling (J), Lawrence Kenneth Steels (J).

Continued on page 133



## BIG OR SMALL . . . BENDIX DRIVES START THEM ALL

Throughout the world of transportation it's an accepted fact that *you start with Bendix!* And it's not surprising. Bendix\* Starter Drives have been synonymous with dependability for fifty years in the automotive field. They've proved themselves just as reliable on submarines, aircraft, earth movers, outboard motors, helicopters. In fact, every type of internal-combustion

engine ever built has used a Bendix Starter Drive. Hospitals use Bendix Drives to activate their stand-by equipment. Air raid sirens across the country are started with Bendix Drives. It's logical to believe that such universal acceptance indicates a standard of quality which no other manufacturer has been able to match. Need we say more?

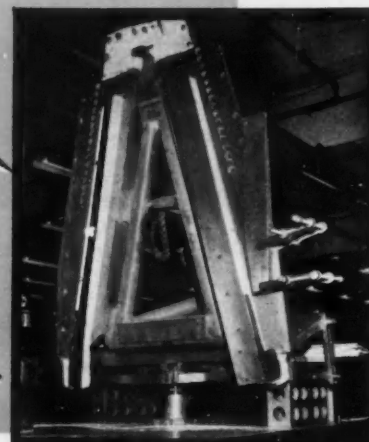
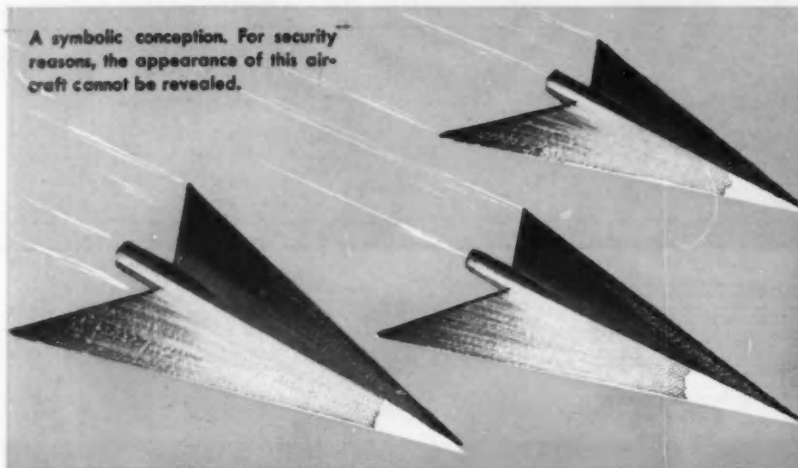
\*REG. U. S. PAT. OFF.

**Bendix-Elmira, N.Y.**

ECLIPSE MACHINE DIVISION



A symbolic conception. For security reasons, the appearance of this aircraft cannot be revealed.



A master drill and setting gauge, showing use of Epon resins to duplicate compound curves and contours.

## In building the supersonic Arrow . . .

Avro Aircraft, Limited saves time and money with

# EPON<sup>®</sup> RESIN

dies, tools, jigs, molds and fixtures

Avro Aircraft, Limited—developing Canada's supersonic Arrow—is achieving major savings with Epon resin tooling.

Epon resins provide faster, lower cost preparation of stretch dies, forming tools, drop hammer dies, jigs, duplicate master die molds, checking and assembly fixtures. Avro reports that in making dies of Epon rather than metal, manpower requirements are two-thirds less, which is reflected in correspondingly great savings in the unit cost of tooling.

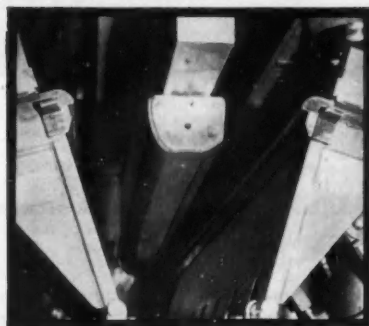
The Epon resins have an ideal combination of properties for tooling applications. To list just a few:

- Exceptional dimensional stability, high impact strength, excellent resistance to abrasion, minimum residual stress in cured parts.
- Ease and speed of preparation.
- Low shrinkage in filled formulations, assuring perfect master reproduction; minimum warping and stresses.
- Adaptability to repairs and design changes.
- Minimum finishing requirements for smooth surfaces.

Like Avro, other leading manufacturers report savings as high as 80% with Epon resin tools and dies—for production as well as experimental and short-run work. Can you make comparable savings in your own operations? Find out by writing for technical literature on Epon resins for tool and die applications.



Epon-faced die requires only hand rubbing to achieve smooth finish. Radii are being touched up with sander.



Stretch die, with Epon resin facing of involved contours, ready for run on 800-ton press.

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IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited • Montreal • Toronto • Vancouver



## New Members Qualified

continued

### New England Section

Richard L. Bates (J), Chester A. VanderPyl (M), Joseph Witkum (M), Morris B. Wood (M).

### Northern California Section

Lt. Jg. William H. Albee, Jr. (J), John Harkins (J), Herman H. Isheim (A), Edward C. McLaughlin (M), Don A. Swain (M).

### Philadelphia Section

Sidney H. Abrams (M), Harvey W. Bush (M), David C. Fariss (M), Herman Frederick Hoffmann (J), Alexander J. MacRae (M), John K. Titus (A).

### St. Louis Section

Louis E. Astroth (J), Richard L. Fisher, Jr. (J), Donald C. Hill (M), Leroy David Jansen (J), Orville H. Rinne (J), Robert Frank Schuman (J), Thomas A. Sullivan (M).

### San Diego Section

Charles Douglas Beckner (J), Henry L. Behl (M), Tommy Dale Duncan (J).

### Southern California Section

Charles R. Bane (M), Bruce Urlin Benedict (J), Gilbert Edwin Bielefeld (J), Karl E. Giesler (A), Ronald Duane Irvin (J), Charles H. Jackson (J), Karl Kenneth Kerns (J), Stephen Jerome Markoski, Jr. (J), R. B. Moulton, Jr. (J), Arthur Nielsen (J), Raymond H. Rice (M), Henry A. Roth, Jr. (J), Dr. Benjamin L. Scheaffer (J), Josef E. Wuerer (J).

### Southern New England Section

Otto Paul Karp (M), Roger A. Lautier (M), Howard W. Nelson (J), Winthrop B. Vail (M).

### Texas Section

Alvin Hill (M), Bruce Forrest McCall (J), Richard Earl Witte (J).

### Texas Gulf Coast Section

Clinton Eugene Bennett (M), Eugene W. Buckles (J), J. Taylor Hood (M), Walter E. Liljestrand (M), Joe D. Little (M).

### Twin City Section

Harold Leigh Julian Aga (A), Oliver W. Johnson (J), Jerome A. Trapp (A).

### Virginia Section

Robert B. King (A).

Continued on page 134



# MIDLAND

## WELDING NUTS

### Cut Assembly Time . . . Insure Proper Fit of Metal Parts

Modern designers of metal parts are finding Midland Welding Nuts a simple, low-cost means of insuring strong, bolted unions at hard-to-get-at places. Once the nut is welded into position at the exact location, the bolt can be easily turned into it without requiring a holding device on the nut. This not only means a saving in assembly time, but often results in one man being able to do a job previously requiring two.

If you're a manufacturer of metal parts, you can enhance your product appeal and at the same time pass along substantial savings to your customers if you use Midland Welding Nuts. By equipping your product with these lock-sure nuts, assembly flows uninterruptedly and parts fit accurately. Welding nuts are applied in a matter of minutes, last the long life of your product.

Inquire about this economical convenience today. You'll find it pays for itself over and over again.

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Export Department: 38 Pearl St., New York, N. Y.

AUTOMOBILE and TRUCK FRAMES

• AIR and VACUUM POWER BRAKES

AIR and ELECTRO-PNEUMATIC DOOR CONTROLS

# The Permanent Magnets that are really **PERMANENT!!**

Stackpole Ceramagnet (ceramic) permanent magnets offer maximum coercive force and other distinctive advantages for mechanical (holding), electro-mechanical, electronic, polarizing and many other applications.



CERAMAGNET DIVISION  
**STACKPOLE CARBON COMPANY**  
St. Marys, Pa.

**STACKPOLE**  
*CeraMAGNET*  
**CERAMIC MAGNETS**

## New Members Qualified

continued

### Washington Section

Edward J. Duncan (A).

### Western Michigan Section

James Bruin (J), Dan Blaine Kuiper (J).

### Wichita Section

William J. Howell, Jr. (M).

### Williamsport Group

John Q. Steely, Jr. (A).

### Outside Section Territory

Thomas M. Adams (A), Gerald A. Doetsch (A), Clarence D. Fox (J), Victor F. Hunt (M), Warren J. Kopf (M), Adrian J. Moorhead (M), Carl H. Parker (M), Charles C. Rape, Jr. (A), Waldo E. Rodler, Jr. (M), James Robert Slater (J), George A. Smith (M).

### Foreign

Armando Carvajal Alegre (M), Cuba; Edward A. Driessen (M), Netherlands; Donald M. Robertson (M), Australia; Thomas William Sommers (A), Australia.

## Applications Received

The applications for membership received between Sept. 10, 1957 and Oct. 10, 1957 are listed below.

### Atlanta Section

E. I. Bricker, Robert O. Dickinson, Jr., Robert D. Gilson, B. A. Martin, Jr.

### Baltimore Section

George T. Adams, Jr., Mason Joseph Reilly.

### British Columbia Section

J. S. McDuff.

### Buffalo Section

Frank J. Flis, Jr.

### Canadian Section

Lloyd Anderson, Benedictus L. de Jooe, W. Cameron Durie, Ian F. Flemming, Earl H. Forrest, Donald Matheson Grant, Edward James Hearn, Nor-

Continued on page 136



# NOW!

FOR THE FIRST TIME,  
A BASIC MANUFACTURER OF RESINS  
OFFERS A COMPLETE LINE OF  
PLASTIC TOOLING MATERIALS—

## RCI POLYTOOL

The Reichhold POLYTOOL line of plastic tooling materials includes epoxy, polyester, phenolic and polyurethane resins; resin compounds and hardeners. Reichhold is a leading manufacturer of synthetic resins. This means outstanding quality control...your assurance of uniform dependability...materials tailored for casting, laminating and other techniques used in all types of plastic tooling. Write to RCI for full details on the POLYTOOL line and let RCI's specialists help solve your plastic tooling problems.

Creative Chemistry . . .  
Your Partner  
in Progress



### REICHHOLD

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Formaldehyde • Glycerine • Phthalic Anhydride  
Maleic Anhydride • Sebacic Acid • Sodium Sulfite • Pentaerythritol • Pentachlorophenol • Sulfuric Acid

## Applications Received

continued

man Robert Kitchen, Malcolm David Prentice, Carl David Purdy, James Edward Scranton, Ronald Wilson.

### Central Illinois Section

Donald R. Amborski, Kenneth W. Campen, Wallace M. Catanach, Jr.,

Ralph J. Charter, Thomas Cook, James R. Hill, Jerry Martin Justice, Earl Melvin Kerr, Harvey Warren Liberman, James A. Memmer, Wayne P. Meyer, R. V. Pearson, Robert E. Rohman, Jack A. Rupert, Henry G. Sinnock, Richard Wayne Walker, Robert W. Young, Jr., Byron D. Zehr.

### Chicago Section

Harold Bennett, John F. Bowski, Carl F. Brock, John James Durkin, Edward C. Harnach, Jr., Henry Fred

Janus, Eugene E. Manley, Dean A. Matthews, Walter Penzias, Larry James Taft, James W. Tharp, Willard F. Wadt.

### Cincinnati Section

Donald P. Holmes, James Arthur Maston.

### Cleveland Section

Kenneth Joseph Baumeister, Charles N. Drechsel, Edward William Gomersall, Harry J. Grospitch, Robert Creston Hudson, Frank A. Jeffries, Thomas J. Loftus, John A. Matz, Ralph Miller, Gene E. Myers, Peter Abba Orner, William Patrinos, Willis W. Stuart, Charles D. Thompson, Robert E. Tucker.

### Colorado Group

Robert O. Nagel.

### Dayton Section

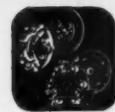
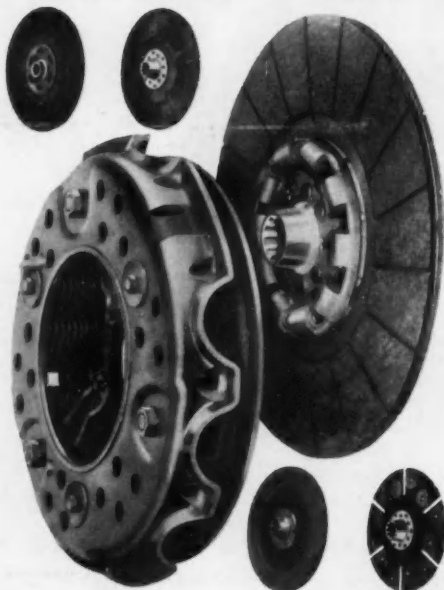
Paul A. Haines, Jr., Norman Chris Johnson, James A. Weybright.

### Detroit Section

Arthur A. Adams, Bohdan A. Andrushkiw, Peter Ashurkoff, Stephen Avakian, Guy L. Barnes, Jr., James S. Brierley, Lawrence Paul Brissette, Roy E. Calcagno, James O. Cardot, Richard A. Carlson, William D. Casey, William Smith Christenberry, Robert W. Clark, Earl W. Cunningham, Charles W. Daberkoe, John E. DeCou, Jr., Myron D. Dickey, Daniel William Doran, John E. Eckenrode, Jr., Sonny Grey Edwards, Victor E. Eicher, Robert E. Farrell, Harold Saum Ford, Charles Russell Frederick, Donald Everett Goss, Herman J. Greif, Jr., Gerhard Karl-Friedrich Haas, John E. Haines, Richard P. Halbach, E. Eugene Hancock, Roger H. Harrison, Dexter R. Hart, John A. Hohman, Paul P. Huber, Leigh F. Jackson, Myron Carl Johnson, Donald J. Karalash, Bomi Dinshawji Kerawalla, Robert W. Keyser, Robert D. Knoll, Raymond A. Kobe, H. Bernhard Kulose, Jesse R. Laugherty, Roy M. Law, James L. Lempke, Joseph D. Loveley, J. Edwin MacAfee, Ronald Anthony Makowski, Raymond Arthur McAlpine, William Robert McGregor, Matthew Frank Meleski, Jr., Norman W. Miller, Kenneth T. Milne, Jr., Eric Mittelstadt, John J. Mooney, E. Ray Morrill, Harold M. Morrison, Neil A. Newman, Herman R. Nichols, Ben C. Parr, Frederic Noel Parrill, Jr., Kenneth George Peterson, Everett F. Petrak, Richard B. Pratt, Albert E. Roller, Joseph J. Serritella, Robert Arthur Shuman, Arnold Alfred Skarjune, Harry W. Smith, Robert James Smith, James R. Stimpson, Vernon Swan, Robert E. Thoreson, Kenneth Leslie Thorpe, Fred F. Timpner, Michael Tsou, C. E. Valentine, III, Marius A. van Merkensteijn, Harold L.

Continued on page 139

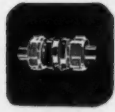
# ROCKFORD



Small  
Spring Loaded



Heavy Duty  
Spring Loaded



Oil or Dry  
Multiple Disc



Heavy Duty  
Over Center



Power  
Take-Offs



Speed  
Reducers

## A Clutch Plate—for Every Use

ROCKFORD CLUTCHES are made with a wide variety of friction plates—to meet your specific needs exactly. Organic, metallic, segment or Morlife® cerametallic facings provide the right torque, wear and heat resistance characteristics. Cushioning arrangements minimize the effects of shock-load engagements. Dampeners blot out vibration and chatter. Pressure plates of high tensile strength resist centrifugal force of modern high speed engines. These ROCKFORD advantages will help you select the right friction clutch for your particular needs.

**SEND FOR THIS HANDY BULLETIN**  
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

**ROCKFORD Clutch Division BORG-WARNER**

316 Catherine St., Rockford, Ill., U.S.A.  
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

# CLUTCHES



**Should your  
GEAR DEPARTMENT  
be in Richmond, Indiana?**

This possibility is worth your consideration. Many of our best customers use us in this manner—as their *gear department*—with all of our facilities geared to their gear needs. Would you like to learn how successful these associations have been, and what a similar service might mean to you in terms of reduced costs and better gears?

Our Sales people are gear engineers. Would you like to talk to one? Write us at Richmond, Indiana—gear headquarters for many of America's leading industries.

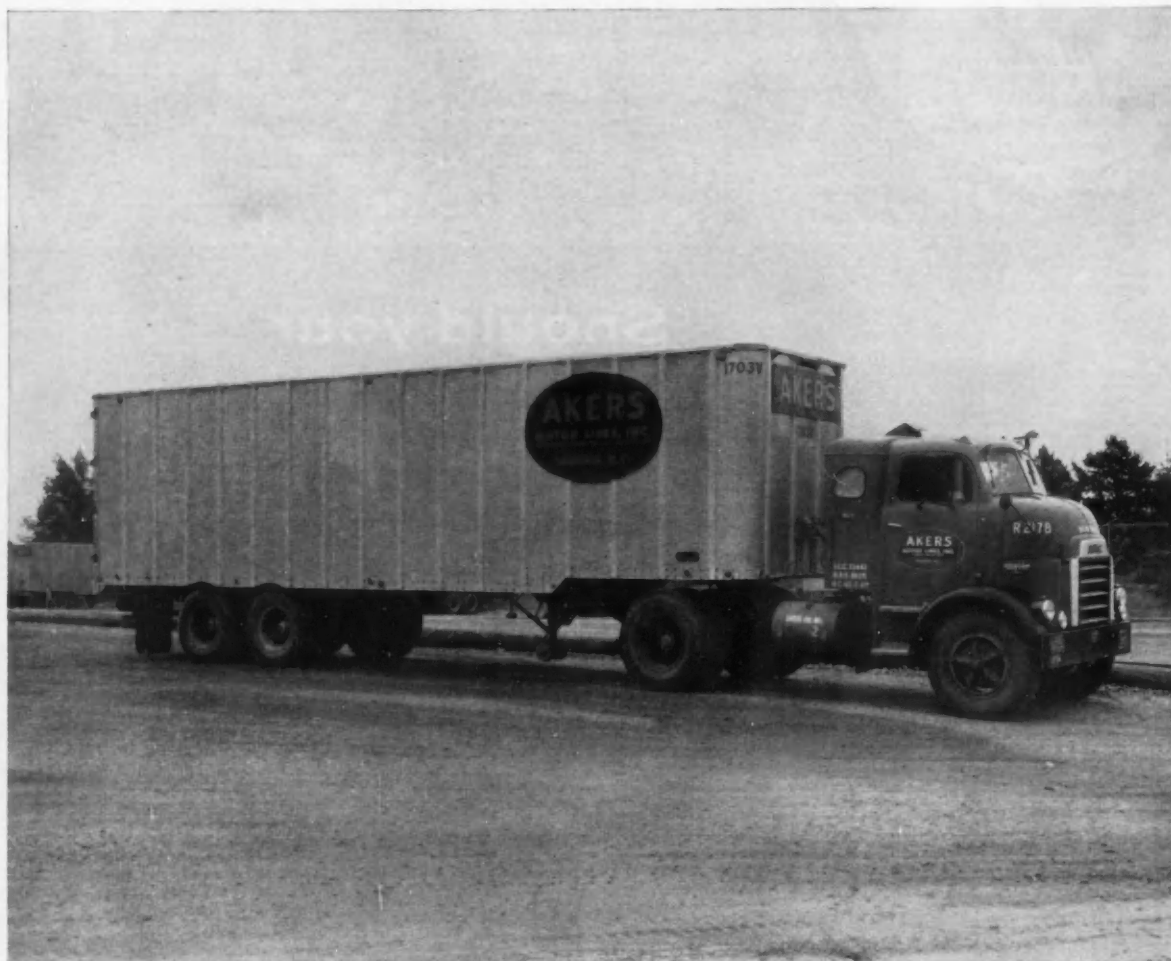
# EATON

**AUTOMOTIVE GEAR DIVISION  
MANUFACTURING COMPANY  
RICHMOND, INDIANA**



GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS  
GEAR-MAKERS TO LEADING MANUFACTURERS





One of Akers' 40 new GMC DF-862 diesel powered units equipped with Fuller 10-speed R-96 ROADRANGER Transmission.

## 40 more FULLER ROADRANGER® Transmissions added to Akers' fleet

To Akers' original fleet of 10 GMC 860 tractors, 40 new GMC DF-862's are now being added...and *all 50* are equipped with Fuller 10-speed R-96 semi-automatic ROADRANGER Transmissions. Says William H. Tomlin, Assistant to the General Manager and Superintendent of Equipment, Akers Motor Lines, Inc., Gastonia, North Carolina: "We are very pleased with the service that the Fuller ROADRANGER Transmissions are giving us. They are a favorite with our drivers."

Fuller ROADRANGER Transmissions give Akers Motor Lines:

- Easier, quicker shifts—28% steps between ratios
- One shift lever controls all 10 forward and 2 reverse speeds
- No gear splitting—10 selective gear ratios are evenly and progressively spaced
- Engines operate in peak hp range with greater fuel economy
- Less driver fatigue— $\frac{1}{3}$  less shifting
- Range shifts pre-selected—automatic and synchronized
- Compact space-and-weight-saving economies—the most compact 10-speed transmission available
- Transmission weight under the cab—permitting more cargo to be carried on the payload axles

Get full facts on Fuller ROADRANGER Transmissions from your truck manufacturer or truck dealer now!



FULLER MANUFACTURING CO. Transmission Division • Kalamazoo, Mich.  
Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest. Dist. Office, Tulsa 3, Okla.

## Applications Received

continued

Vogler, Kenneth H. Wern, John H. Whitney.

### Hawaii Section

Harold D. Andrade.

### Indiana Section

Thomas W. Baker, S. R. Conwell, Eugene Dent, James A. English, Charles P. Lamb, Jr., James M. Leahy, Lowell Gene Stohler, Walter F. Weiss.

### Kansas City Section

Donald K. Edens, Nick J. Itsines, Donald Lee Rich.

### Metropolitan Section

Lloyd G. Angeloff, Bohdan R. Bereznycky, Thomas Edward Collier, Nelson M. Dias, Fred Arthur Grauman, Sanford Halter, Walter F. Hayes, Frederick Lowell Jonach, John Milton Jordan, Paul A. Larivee, Einar Erik Sven Malmberg, Mario L. Marchese, Norman Neiman, Neal Alan O'Keefe, Bernard Rome, Frank A. Tessitore, Frank Tubeck.

### Mid-Continent Section

Joseph Milton Case, Jack E. Foley, C. A. Hubble.

### Mid-Michigan Section

George Arthur Brown, James F. Cutler, James Edward Fent, John Frederick Goodspeed, Robert Joseph Hornacek, Joseph Frank Kolder, Theodore N. Louckes, Ivan K. Lukey, Keith W. Miller, Edward J. Stadler, Edgar R. Whitney.

### Milwaukee Section

Martin Drapkin, Ralph P. Eglsaer, Ben Grob, Nils E. Heden, Hebert G. Heimann, Lester M. Koelsch, Allen J. Malsack, Donald A. Meyerhofer, Charles E. Moeller, Armin E. Nierode, Melvin Harvey Page, Rudolph H. Schneider, David Charles Schweitzer, Charles J. Sperr, Jr., Robert J. Sroka, Willard O. Tschantz.

### Mohawk-Hudson Section

William B. Philipbar, Jr.

### Montreal Section

Frederick Russell Cowley, Roger Legault, William Sydney Longhurst, Greg. G. E. Trudel, Andre Veronneau.

### New England Section

Peter Brownell, Gerard (Jerry) A. Desjardins, Wesley Gordeuk, Perry Johnson, Horace Cheney Lyndes, Fran-

cis J. Post.

### Northern California Section

Norman A. Avedian, Delbert D. Ehrlich, John W. Freund, Walter Henry Giese, Franklin D. Holt, Bevan Herbert Johnston.

### Northwest Section

John A. Ardington, Kenneth John Fehrenz, Harry A. Hescox, Gordon V. Johnson, Hideo Kawata, Donald B. Menzies, Roger A. Molt, Frederick Allan Raupp, Ronald Alfred Winger.

### Oregon Section

David L. Smith.

### Philadelphia Section

Frederick C. Bowman, Paul E. Hag-

strom, Dennis C. Slattery, Al Lawrence Smith.

### Pittsburgh Section

John Marion Coffen, Chester F. Klages, Jr., Frank J. Kowalski, Luis Alberto Ricardo.

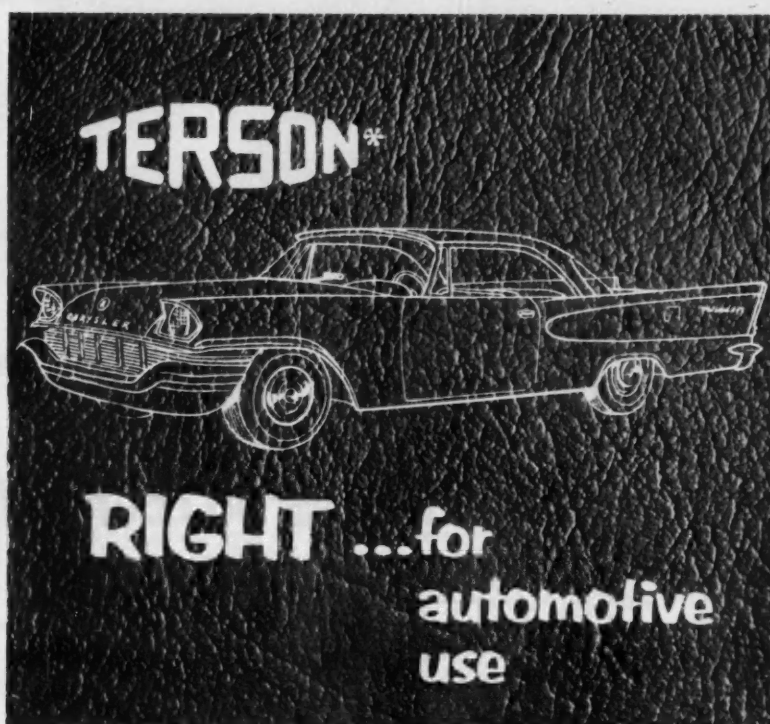
### St. Louis Section

Leonard S. Echols, Charles W. Fowlkes, Ralph W. Shipp, Hartland B. Ukes, Kenneth T. Walden.

### San Diego Section

Sumner Alpert, John W. Baxter, Willis John Christman, Alan LeRoy Clarke, Harry L. Gilmore, David Theodore Kjell, Jr., Robert James Mack, Walter D. Metcalfe.

Continued on page 141



## Consistent Production in Accordance with your Exact Specifications

Rigid quality controls assure uniformity of every shipment. This, plus Athol's many years of experience and continuous research in the coated fabric field, spells out the reason why this skilled producer is being specified by more and more large users in the automotive industry. Inquiries invited.

### VINYL FABRICS FOR AUTOMOTIVE USE

Strategically located plants at Butner, N. C. and Athol, Mass.

## ATHOL MANUFACTURING COMPANY

\*Reg. U. S. Pat. Off. NEW YORK • ATHOL, MASS. • CHICAGO



## NEW TRANSMISSION OIL COOLER— another First for ALLEGHENY STAINLESS

Over 70% of today's cars are powered with automatic transmissions. Fine for the motorist, but new problems for the designer. Transmission oils zoom to 300 degrees and must be cooled.

Solution? Mount a small, efficient heat exchanger within the lower tank of the radiator, as shown above. Make it able to stand wide temperature differentials—surrounding cooling water from 0° to 180°; searing oil of 300°. Make it corrosion proof—against all types of water, all varieties of anti-freeze compounds, dirty, hot oil. Since it's tucked inside the radiator, make it strong and maintenance-free.

Allegheny 430 Stainless Steel has proved itself to meet all these

design objectives. And it actually reduced unit cost over other materials while still improving performance. The ductility and corrosion resistance of this straight chromium stainless make it a natural for this type of application.

Perhaps *your* product could be improved by a switch to Allegheny 430. It costs less than chromium-nickel stainless grades, it's always readily available, not subject to nickel shortages. To find out how Allegheny 430 Stainless can help you, write for the Technical Bulletin described below or call the Allegheny Ludlum Sales Office nearest you.

*Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 6782



Write for this 16-page Technical Study that describes alternate selections available for the Chrome-Nickel Stainless Steels. Gives properties, fabrication data, etc.

ADDRESS DEPT. SA-95

Make it BETTER and LONGER LASTING with

# ALLEGHENY STAINLESS

Warehouse stocks carried by all Ryerson steel plants



## Applications Received

continued

### South Texas Group

B. C. Dial, Thomas James Patterson, William P. Teich.

### Southern California Section

Bennie L. Arce, William H. Bettes, Jr., J. D. Birdwell, Louis C. Brownlee, Jr., Joseph Darrel Cypher, Alvin L. Dubrow, Donald Roy Gates, Everard P. Larned, James J. Loggie, Gene Pierre Monden, George R. Noble, Mackey J. Real, Jr., William Schoellkopf, Jr., Alexander Alley Smith, Jr., Sampson James Smith, Jr., W. F. Snelling, Willard D. Sparkman, James Donald Timm, Juji Wada, Henry Richards Zahner.

### Southern New England Section

David J. Asquith, Clarence R. Libby, M. Allen Magid, Edward R. Primachuk, Clyde A. Walb, Jr.

### Spokane-Intermountain Section

Robert G. Anderson, Francis O'Connor.

### Syracuse Section

Clare Louis Frisbie, John Winston Kramar, Maurice L. Swartz.

### Texas Section

Nick A. Birbilis, Norbert A. Kouyoumojisky, Harold Vaughn Lindow, Joseph Alonzo Ramirez, Jr., Louis Vincze, Jr.

### Texas Gulf Coast Section

Otis W. Boteler, Fred N. Lamoureux.

### Twin City Section

James V. Brady, Sherwood R. Mickelson, Rodger M. Swanson.

### Western Michigan Section

Richard Davis Follrath.

### Williamsport Group

John F. Fowler, Jr., George Richard Kratzer.

### Outside of Section Territory

Donald D. Baker, Gene Richard Drew, Edward Perry (Pete) Espenschied, Barnett Frumkin, Richard H. Guscott, Wilford G. Kilpatrick, George Henry Milford, Elmer Robert Rathgeb, Ralph E. Siegel, Charles Wayne Taylor, Robert C. Tefft, Robert H. Tweedy, Edwin A. Weaver.

### Foreign

Philip Charlton, New Zealand; Antonio Hideto Kobayashi, Brazil; Donald J. Kohsiek, Switzerland; Robert Leadbitter, Bermuda; Sylvio de Aguiar Pupo, Brazil; P. K. Ramachandran Nair, India; Madahath Mohamed Salih, Ceylon; Louis A. Sellier, Venezuela; A. V. Varughese, India.

## CONTINENTAL RED SEALS



... *are Engineered*  
*to Fit the Job*

You find Red Seals on the job, wherever there's a job to be done—in excavating, ditching, concrete ripping, grading, building, and all phases of road construction. You find them powering the equipment of manufacturers who recognize the importance of the "engineered for the job" features, and the day-in, day-out dependability of Continental Red Seal engines and power units. . . . The Badger Machine Company's Model 360 Hydro-Scopic Hopto, shown above, is powered by a Continental Red Seal Model B427. This installation is another fine example of expert matching of the engine to the rest of the machine. It's wise, when buying equipment of this type, to choose a make with Red Seal power. You get an engine which is not only tailored to the job, but backed by specialized experience dating from 1902.

SERVICE FACILITIES AND GENUINE RED SEAL PARTS ARE AVAILABLE EVERYWHERE

WORLD'S LEADING INDEPENDENT MANUFACTURER OF INTERNAL COMBUSTION ENGINES. CONTINENTAL MOTORS OPERATES PLANTS IN ATLANTA, DALLAS, DETROIT, MILWAUKEE, MUSKEGON, AND TOLEDO, AND IN ST. THOMAS, ONT., PRODUCING AIR-COOLED AND LIQUID-COOLED ENGINES FOR USE ON LAND, AT SEA AND IN THE AIR.

**Continental Motors Corporation**

MUSKEGON • MICHIGAN

# Maybe you're paying for top quality "Commercial Grade" Roller Bearings... **BUT ARE YOU GETTING THEM?**

**T** rue, there's a wide difference in quality and cost between the low-range and high-range of any "commercial grade" bearing. But every Rollway Tru-Rol "commercial grade" bearing approximates as closely as possible maximum standards of construction consistent with the price.

*Take the matter of separators, for example:* In Rollway bearings, separators give maximum guidance to each roller. The result is greater total load capacity and longer life.

Equal spacing of rollers means uniform distribution of load. The result is the elimination of destructive "pulse" and vibration.



Cutaway view of Rollway Tru-Rol® segmented-retainer roller bearing  
... one of three distinct types of Tru-Rol bearings available.

Moreover, separators are of deep section, formed to the curve of the rollers, giving true axial alignment, smooth-surface contact and an even lubrication film on each roller.

It's little things like these that mount up to big savings in service. Check the accompanying list,

or ask a nearby Rollway Service Engineer to explain in detail the quality you should be getting in your "commercial grade" bearings. No cost. No obligation. Just write us. Rollway Bearing Co., Inc., 586 Seymour St., Syracuse, N. Y., *manufacturers of a complete line of radial and thrust cylindrical roller bearings.*

ENGINEERING OFFICES: SYRACUSE • BOSTON • CHICAGO • DETROIT • TORONTO • PITTSBURGH • CLEVELAND • MILWAUKEE • SEATTLE • HOUSTON • PHILADELPHIA • LOS ANGELES • SAN FRANCISCO

## *Check This List* AND BE SURE!

### **Retainer Operation**

- ☐ Is the retainer roller-supported, to reduce sliding friction?

### **Retainer Construction**

- ☐ Is the retainer strong enough to withstand shock loads and sudden reversals?

*(A Rollway segmented-type steel retainer, such as that illustrated, is the strongest, most durable available in commercial grade bearings.)*

### **Roller Spacing**

- ☐ Are all rollers equally separated, or do some rub against each other in opposed-motion friction?
- ☐ Are rollers distributed evenly to prevent "pulse" and vibration?

### **Roller Construction**

- ☐ Are the rollers crowned for optimum load distribution?

**For Top Quality in Every Detail Buy Tru-Rol and Be Sure!**



# Don't buy O-rings blindly!



## Prove by comparison tests that Parker O-rings seal better, last longer

Comparison tests will show you that Parker O-rings are better. You can't *see* the difference. You can't *feel* the difference. But in *use*, Parker O-rings actually do seal better and last longer!

Why? Because Parker O-rings are precision-molded of superior compounds developed by exhaustive research and experimentation. Our engineering service will help you with your particular problems — whether in gland design or compound. From Parker, you get the *right* O-ring for your *specific* application. Compare Parker O-rings and

discover the difference for yourself.

These trouble-free, leakproof seals are carefully evaluated for elongation, tensile strength, compression set ratings, resistance to oils, fuels, chemicals and temperature extremes. Exacting laboratory and service tests make sure that Parker O-rings meet applicable specifications. Whatever your requirements, Parker can supply the O-rings you need.

Ask your Parker O-ring distributor today for new O-ring Size Catalog or mail the coupon for your copy.



Parker O-Lube is especially formulated for O-ring lubrication requirements. It comes in a handy, squeeze-tube container.

**Parker**  
Hydraulic and fluid  
system components

### RUBBER PRODUCTS DIVISION, Section 525-GC

The Parker Appliance  
Company,  
17325 Euclid Avenue,  
Cleveland 12, Ohio.

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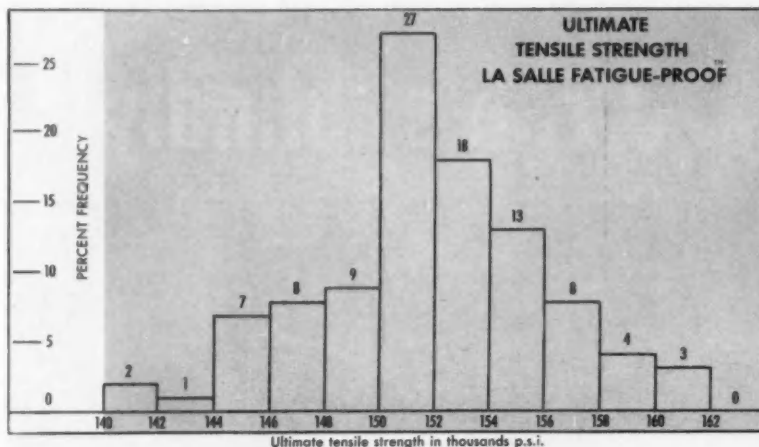
- ☐ O-ring Size Catalog No. 5701  
☐ O-Lube Catalog No. 5840

NAME \_\_\_\_\_ TITLE \_\_\_\_\_

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_ STATE \_\_\_\_\_



The above chart shows the range of ultimate tensile strength over a period of one year's production. Average value obtained is approximately 150,000 p.s.i.

## "e.t.d."™ Process Applied to FATIGUE-PROOF™ Steel Bars Gives Added Strength, Greater Uniformity, Better Machinability

Guaranteed 140,000 p.s.i. minimum tensile... no heat treating necessary

Six important physical and mechanical properties, (1) a high strength level, (2) exceptional uniformity, (3) improved machinability, (4) wear resistance, (5) resistance to fatigue, and (6) dimensional stability, are desirable features of La Salle "FATIGUE-PROOF" steel bars, produced by the new "e.t.d." (Elevated Temperature Drawing) process.

**Strength...** "FATIGUE-PROOF" is a carbon steel bar which replaces both hot-rolled or cold-finished carbon and alloy heat-treatable steel bars. Production figures show hardnesses between Rc 30 and Rc 36 (with a minimum hardness guarantee of Rc 30). The guaranteed minimum tensile strength is 140,000 p.s.i. with a 150,000 p.s.i. average.

"FATIGUE-PROOF" is better than a heat treated bar because it is not quenched and tempered and so the problems frequently associated with quenching and tempering such as (1) quench cracks, (2) non-uniformity of section, (3) soft centers, and (4) heat treat distortion are eliminated. Costly secondary operations such as grinding, cleaning, and straightening are not necessary. Rejects are minimized.

**Exceptional uniformity...** "FATIGUE-PROOF" is remarkably uniform from bar to bar, end to end, size to size, and lot to lot. Design and production engineers can depend upon it being the same from day to day and job to job.

Individual processing of each bar plus the inherent good qualities and characteristics of the "e.t.d." process account for the excellent uniformity. Microstructures are uniformly pearlitic.

**Improved machinability...** "FATIGUE-PROOF", made by "e.t.d.", machines 50% to 100% faster than heat treated alloys, and 25% faster than annealed alloy steels. It machines with a very fine finish, and gives excellent tool life. These characteristics make it an ideal steel for production parts.

**Wearability...** Field applications such as gears, pinions, pins, and screws prove that "FATIGUE-PROOF" has good wear resistance. It resists galling and seizure, partly due to its hardness... and probably due to the anti-weld characteristics of its chemistry. Further, "FATIGUE-PROOF's" pearlitic structure appears to resist sliding wear better than a quenched and tempered structure of equal hardness.

**Resistance to fatigue...** The chief reason for the failure of highly stressed parts is fatigue. While part shape, unfavorable residual stresses, tool marks, gouges in highly stressed areas, and many other factors contribute to fatigue failure, most materials have also an inherent quality... endurance limit that is an indication of ability to resist fatigue.

"FATIGUE-PROOF" has this inherent

quality to resist fatigue. Laboratory tests prove that fatigue properties are at least comparable to those of expensive heat treated steels of the same strength level. Numerous field tests, under severe operating conditions, have proved this to the satisfaction of many manufacturers.

**Dimensional stability...** "FATIGUE-PROOF" maintains a high degree of dimensional stability in machining because of its low order of residual stresses.

**Details of the "e.t.d." process...** Elevated Temperature Drawing involves (1) the selection of bar chemistry, (2) the amount of reduction in cross-sectional area of the bar as it is drawn through a special die, and (3) a preselected elevated drawing temperature which will result in the desired final properties.

Although the "e.t.d." process was first announced early in 1957, it has been used in the production of "FATIGUE-PROOF" steel bars since September 1955. Four U.S. Patents (Nos. 2,767,835, -6, -7, and -8) were granted October 23, 1956, covering the "e.t.d." process — an exclusive development of La Salle Steel Company.

### How manufacturers can obtain sample Fatigue-Proof steel bars for testing

LaSalle Steel Company has announced that samples of "FATIGUE-PROOF" steel bars, made by the "e.t.d." (Elevated Temperature Drawing) process, are available for test purposes on a no charge basis to manufacturers where it appears that "FATIGUE-PROOF" can help improve products and reduce production costs.

Applications for a sample bar are invited from manufacturers making parts from either hot-rolled or cold-finished carbon or alloy steel bars which require high tensile strength.

Interested manufacturers may write for a test sample by sending a blueprint or application details direct to LaSalle Steel Company, Advertising Department, P. O. Box 6800-A, Chicago 80, Ill.

"FATIGUE-PROOF" is also available from your steel distributor... write for his name.

### Brochure tells story of Fatigue-Proof steel bars

"A New Material" is the title of a 24-page booklet which gives detailed information covering La Salle "FATIGUE-PROOF" steel bars made by the Elevated Temperature Drawing process.

The booklet presents the results of more than one year's tests of production samples and reports on eight application case studies. Copies available on request.

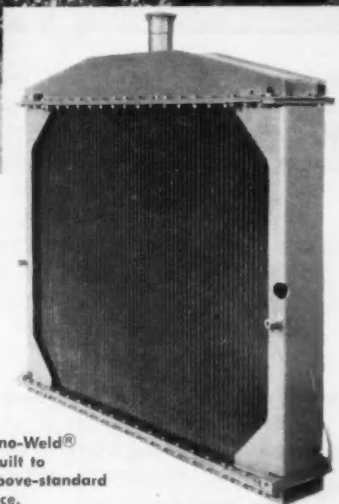
TM—Trademarks of La Salle Steel Company



**La Salle STEEL CO.**

1458 150th STREET  
HAMMOND, INDIANA

# 18 TONS OF COPPER ORE ...COMING UP!



Young Mono-Weld® radiator built to provide above-standard performance.

## **Young** COOLED DART UNDERGROUND TRUCKS Speed Copper Mining

"Used where the going is tough!" No idle phrase when used about Young radiators—proved again and again to withstand the rough, tough, rigorous conditions typical of the mining operation illustrated above.

Dart Truck Company chose Young radiators to cool their model 18S-UG underground

trucks because Young design and construction guarantees performance that can be relied on. Performance that matches the quality of the trucks in which these radiators form such a vital part.

Young Radiators are specified by the greatest names in industry. Write today for complete information and catalog.

**Young radiators are used where the going is tough!**



Send for catalog No. 148-A today. There is no obligation. Write to Dept. 117-L.

# **Young**

**RADIATOR COMPANY**

RACINE, WISCONSIN

*Creative*

**HEAT TRANSFER ENGINEERS**

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

# REVOLUTIONARY!

## **Victocor** *Motor Seal*

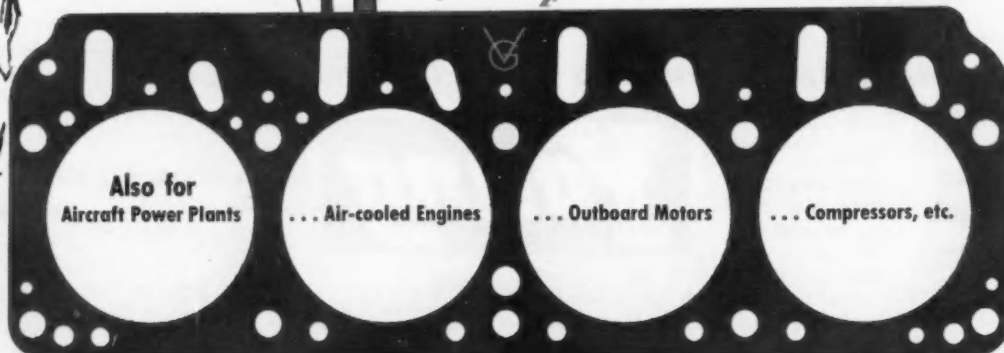


So thin and  
flexible —  
handles like  
fabric

TRADE-MARK (Registration Applied for)



Patents Pending



Also for  
Aircraft Power Plants

... Air-cooled Engines

... Outboard Motors

... Compressors, etc.

# New gasket... strong and thin... ***LOCKS*** all the power in!

Here now—and fully tested—**Victor Motor Seal** insures getting maximum power from engines. It seals in all potential power.

A totally new concept in gasket engineering,

**Victor** is thin... flat... and uses no beads, grommets or flanges. It's flexible—handles easily as fabric—and yet has the resilience of rubber and strength of steel.

## Perfect power seal for high-compression engines

**Victor** stands proved under top compression ratios. It outperforms all other gaskets, with ample reserve to handle still higher pressures and speeds.

Currently, **Victor** material is being developed further for truck, tractor, diesel and fuel injection engine applications.

Exclusive thin steel core construction gives **Victor** accelerated heat conductivity. It prevents loss of torque due to collapsing and pounding under

heavy load. It maintains dimensional stability, while the sealing element positively retains all coolants.

Heat transfer is speeded, on Type 200 for example, by 800 projections per sq. in. formed in the core, projecting alternately on each face.

The sealing element—a specially developed asbestos-elastomeric compound—is bonded simultaneously to core faces.

## Approved original equipment...holds all "built-in" engine power

In use as original parts for the past year, **Victor** head gaskets far exceed ordinary sealing requirements. They insure maintenance of original compression ratio. Their extreme resiliency helps com-

pensate for mating surface irregularities. They outperform gaskets two to three times thicker.

**Victor** needs no pre-coating on installation—comes off without difficulty on replacements.

## 4 types available...specification nonrigid...samples free

**Victor** can be designed to your application from the four different types available. Modification can be made in core and packing combinations. Also, heavier gauges and special constructions can be supplied.

All **Victor** packings have been tested to new high limits for balanced resilience and heat resistance. Maximum performance is assured with any

specific type of **Victor** construction.

Specifications and test samples on four basic types sent on request. With no obligation, your Victor Field Engineer and the factory will be glad to work with you on any proposed application.

Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Limited, St. Thomas, Ont.

# VICTOR

Sealing Products *Exclusively*

**GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS**



## Vibration won't loosen FLEXLOC self-locking nuts

Where products must be reliable... must stand up under vibration, temperature extremes and hard use... designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts.

### HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting locking action. And they are reusable: repeated removal and

replacement, frequent adjustments, even rough screw threads will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 55, Pa.

*We also manufacture precision titanium fasteners. Write for free booklet.*

**FLEXLOC** LOCKNUT DIVISION

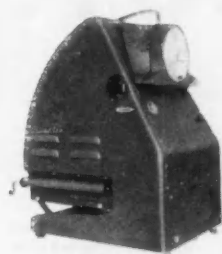
STANDARD PRESSED STEEL CO.

**SPS**  
JENKINTOWN PENNSYLVANIA

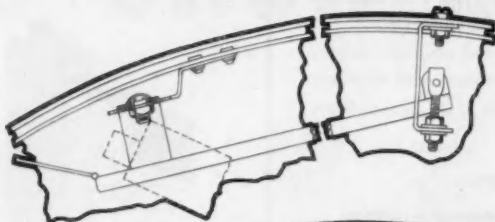
# Waldes Truarc Rings cut assembly costs, improve performance of precision photo-optics equipment

Charles Beseler Co., E. Orange, N. J. uses Waldes Truarc Retaining Rings in 3 applications shown.

## REFLECTING MIRROR ASSEMBLY IN OPAQUE PROJECTOR



VU-LYTE II  
PROJECTOR



### BEFORE

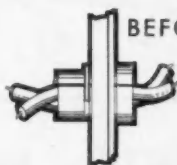
"The front surface mirror is the most precise optical element in a properly-functioning opaque projector," Beseler writes. "Previously we used this extremely cumbersome means of holding the mirror in position. As mirror adjustments are always required and the mirror is extremely delicate, our spoilage was terrific."



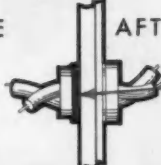
### AFTER

"Two Truarc Series 5100 Rings made possible complete redesign of the mirror assembly. Now mirrors can be adjusted from outside the projector. Rejects now are practically nil. More precise adjustment of the mirror is possible. And because of the greater ease in adjustment, we have cut labor costs \$2.00 per unit."

## HEAT ASSEMBLY IN PRINT DRIER



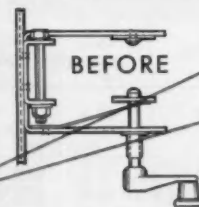
### BEFORE



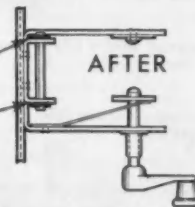
### AFTER

Here a Waldes Truarc crescent ring, Series 5103, replaced a split collar and clamping ring. Results: labor costs cut 50¢ per unit because of greater ease of assembly. Drier provides more uniform heating.

## 35 MM MICRO-FILM NEGATIVE CARRIER IN ENLARGER



### BEFORE



### AFTER

2 Waldes Truarc Series 5133 E-Rings replaced 2 cap nuts—at a saving of 20¢ per unit in labor costs.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get

**Complete Selection:** 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U.S. and Canada.

**Controlled Quality** from engineering and raw materials through to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

**Field Engineering Service:** More than 30 engineering-minded factory representatives and 700 field men are at your call.

**Design and Engineering Service** not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.



**WALDES**  
**TRUARC**  
**RETAINING RINGS**  
WALDES KOHINOOR, INC.  
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.  
Please send new, descriptive catalog showing all types of Truarc rings and representative case history applications. (Please print)

Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Business Address \_\_\_\_\_  
City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

SA119

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,185; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

## Test Shows

# Armco ALUMINIZED STEEL Doubles Average Muffler Life

Actual road tests from 1948 to 1955 showed that automobile mufflers made of Armco ALUMINIZED STEEL® Type 1 outlast carbon steel mufflers at least two to one on the average.

The test was conducted by replacing failed original carbon steel mufflers on privately owned automobiles with mufflers made wholly or partly of Armco ALUMINIZED STEEL. No mufflers were entered in the test after 1952.

Here are some of the significant results:

	ALUMINIZED STEEL	CARBON STEEL
Mufflers With Data Available	150	126
Failed by End of Test	37 %	100 %
Still in Service at End of Test	63 %	0.0 %
Failed Within First 24 Months of Service	4.6 %	42.0 %
Average Service Life of First 37 % to Fail	42.6 Months	18.1 Months
Average Service Life of Failed Mufflers	42.6 Months	29.3 Months
Average Service Life Expectancy of ALL Mufflers, Including Those Still in Service at End of Test	58.0 Months	29.3 Months
Shell Failures	9 %	85 %

### OTHER FINDINGS

Of the 56 ALUMINIZED STEEL mufflers that failed during the test, 44 were returned for examination. On mufflers with some carbon steel parts, more than 70 per cent of the failures were due solely to rusting out of the carbon steel; the ALUMINIZED STEEL parts were still serviceable.

These test results indicate that Armco ALUMINIZED STEEL in any muffler part increases not only the life of that part, but also the average life expectancy of the muffler as a whole. This was especially true of the shell, the most vulnerable component.

Since dual exhaust systems have greatly increased replacement costs, new car owners are especially conscious of muffler life. For a powerful sales advantage, consider mufflers made of Armco ALUMINIZED STEEL for your cars. For complete information on this special steel, write us at the address below.



Here's how a carbon steel muffler looked after only 18 months' service. Heat and products of combustion have caused the shell to fail completely.



This ALUMINIZED STEEL muffler has already given 55 months' service. The shell is unbroken. The special aluminum coating is still protecting the base metal.

## ARMCO STEEL CORPORATION

1077 Curtis Street, Middletown, Ohio

Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation



# ENTER THIS CONTEST ... 90 CASH PRIZES!



## CONTEST RULES

1. Tell in 25 words or less "Why I prefer Albanene tracing paper."
2. Send all entries to K&E Albanene Contest, Box 160, New York 46, N. Y. Enter as often as you wish. There is nothing to buy.
3. Entries must be postmarked not later than midnight, Nov. 30, 1957.
4. Entries became the property of Keuffel & Esser Co. None can be returned.
5. The decision of the judges is final.
6. Winners will be notified by mail. A complete list of winners will be sent upon request, providing request is accompanied by stamped, self-addressed envelope.
7. Contest is open to all residents of continental United States, except employees, and their immediate families, of Keuffel & Esser Co. and its subsidiaries and dealers; its advertising agency; and judges of this contest.
8. Also not applicable to residents of those states where there are prohibitory laws.

## Why I prefer **ALBANENE**® Tracing Paper...

First prize . . . . . \$1500

Second prize . . . . . \$1000

Third prize . . . . . \$ 500

plus 87 prizes of \$25 each!

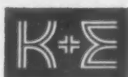
In 25 words or less, tell us why you prefer K&E Albanene® tracing paper. Your reasons may win one of these 90 prizes (it's K&E's 90th anniversary).

**Here's a hint:** Albanene is made from 100% rag stock for superlative tear strength. It is permanently transparentized with an inert resin. Draftsmen like it because of its easy drawing qualities . . . reproduction men for its high transparency and permanence. Everybody likes it because "what you

pay for stays in the paper." That's why Albanene is the best seller among *all* tracing papers.

**Get contest aids** from your K&E dealer: Information booklets, extra contest entry blanks, samples of Albanene, too, if you need them. You can enter as often as you please.

Or use a plain sheet of paper if someone's already snipped the blank below. Give your name, address, and firm name, twenty-five words or less telling why you prefer Albanene tracing paper, and mail to K&E Albanene Contest, Box 160, New York 46, N. Y. before midnight, November 30, 1957.



**KEUFFEL & ESSER CO.**

New York, Hoboken, N. J., Detroit, Montreal, Chicago,  
St. Louis, Dallas, San Francisco, Los Angeles, Seattle.  
Dealers in principal cities

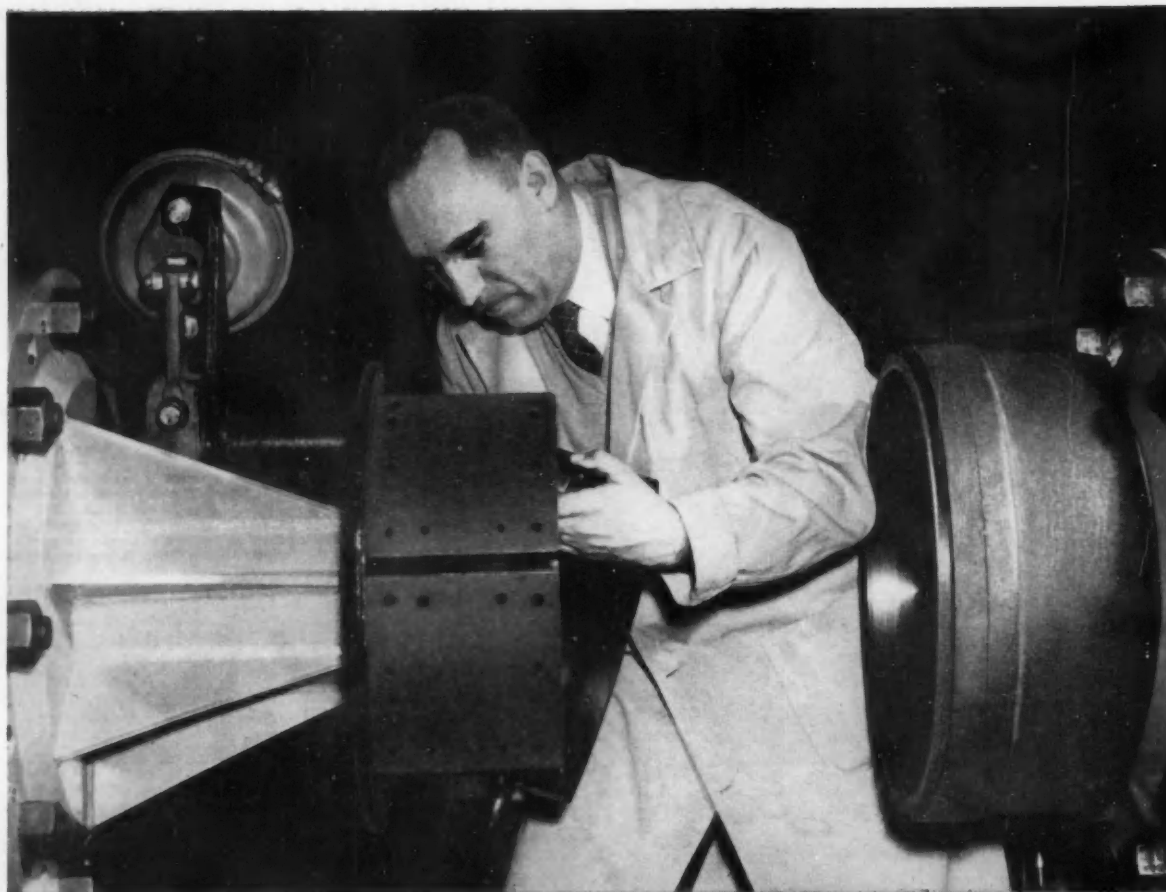
**K & E Albanene Contest, Box 160, New York 46, N. Y.**

Here's why I prefer Albanene Tracing Papers \_\_\_\_\_

\_\_\_\_\_

Name \_\_\_\_\_ City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

Street \_\_\_\_\_ Firm Name \_\_\_\_\_



Experimental block being readied for torture test on Johns-Manville's Inertia Dynamometer—the world's largest unit designed for friction material testing.

## Man in charge of putting more mileage into J-M Brake Blocks

Creating new and better brake blocks is a never-ending responsibility of J-M engineers. Working with the very latest in scientific development equipment, these men are blazing new trails in improved friction material performance.

Over the years, Johns-Manville has offered a wide choice of thoroughly proved, high-quality, high-performance brake linings, brake blocks and clutch facings. This superiority stems from engineering and

production techniques that assure uniformly highest quality. These techniques also provide volume production, rapid delivery and lowest unit cost.

Chances are a J-M material incorporating all the properties you need for your friction applications is already available. If not, let us help you find the solution. The Johns-

Manville engineering staff, a superbly equipped development laboratory, and skill gained through 99 years of manufacturing experience, are at your service.

Your Johns-Manville Representative will gladly tell you more about this service, or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



### Johns-Manville



Molded and  
Woven Brake  
Linings



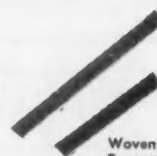
Molded and  
Woven  
Clutch Facings



Molded Brake  
Blocks



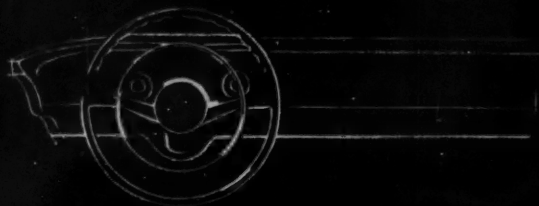
Molded Segments  
for Automatic  
Transmissions



Woven  
Transmission  
Band Linings



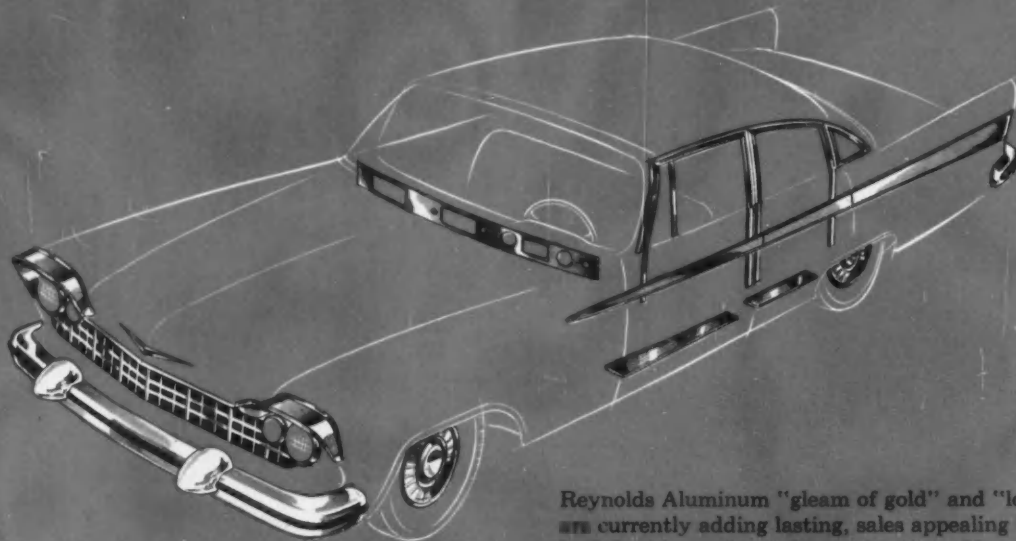
adds colorful, lasting,  
sales appealing beauty...  
increases design flexibility



The Finest Products  
Made with Aluminum

are made with

REYNOLDS  ALUMINUM



The Finest Products  
Made with Aluminum

are made with  
**REYNOLDS ALUMINUM**

© REYNOLDS METALS COMPANY

**Reynolds Aluminum**

THE METAL FOR AUTOMATION

TRADE MARK

Reynolds Aluminum "gleam of gold" and "look of sterling" are currently adding lasting, sales appealing beauty in both interior and exterior applications. Now—for still broader interior use in instrument panels, seat skirts and many trim parts—a variety of exciting finishes are intriguing automobile manufacturers. These aluminum parts will not rust, chip, pit, peel or flake. They create customer appeal . . . assure lasting beauty . . . increase design freedom . . . offer a "new look" at modest cost . . . permit manufacturing economies.

Strong, lightweight aluminum mill products from Reynolds and parts from Reynolds Aluminum Fabricating Service are in wide use in the automotive industry. The photos on this page illustrate examples of Reynolds vast fabricating and finishing facilities. From these facilities come quality parts . . . quality controlled from mine to finished part and backed by Reynolds technological know-how in producing and fabricating aluminum. Economical parts, too, because of Reynolds tremendous variety of the most modern fabricating and finishing equipment.

For details on these facilities and for the assistance of Reynolds Aluminum Specialists on mill product applications or on fabricated parts, contact your nearest Reynolds Office. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan* or *Reynolds Aluminum Fabricating Service, 2010 South Ninth Street, Louisville 1, Kentucky*.



This new Reynolds automatic aluminum finishing system can finish mixed sizes and types of automobile parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



The tanks in this new Reynolds anodizing installation can handle parts 24' long, 12' high and 4' wide, making it possible to handle hundreds of trim parts at one time. This half-block long system is another new addition to Reynolds multimillion dollar finishing facilities investment.



Part of a battery of Reynolds new high speed buffing equipment used here on 1957 hood moldings.



Part of a battery of Reynolds high speed coil fed presses used in the fabrication of automotive parts.

**NOTE:** Before you buy any part—have it priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower final cost.

## Reynolds Aluminum Fabricating Service

BLANKING • EMBOSsing • STAMPING

DRAWING • RIVETING • FORMING • ROLL SHAPING

WELDING • BRAZING • FINISHING

Watch Reynolds All-Family Television Program  
"DISNEYLAND", ABC-TV.

The launching of the world's third nuclear submarine, the Skate, at General Dynamics Corporation's Electric Boat shipyard. The Skate is the first of four nuclear submarines of its type.



*from the SKATE . . .*

## EXPERIENCE FOR TOMORROW'S AUTOMOTIVE FILTERS

What are the filtration requirements of an atomic submarine? Like any filtration problem, they are a combination of factors, such as: the nature of the fluid to be filtered, operating pressures, temperature, corrosion . . . all of which dictate the filter media and form of the filter. The filters must be engineered to meet the specific requirements of the job. That's why the Electric Boat division of General Dynamics Corporation chose Purolator.

The engineering skills and manufacturing capabilities which make it possible for Purolator to

design and build filters for an infinite variety of applications, including nuclear submarines, will produce better automotive filters. In a fast-moving industry, tomorrow's requirements must be anticipated today. Because of its role as designer and builder of filters for all phases of industry, Purolator has, *today*, the experience needed to provide the specific filters you will need for tomorrow's specific requirements.

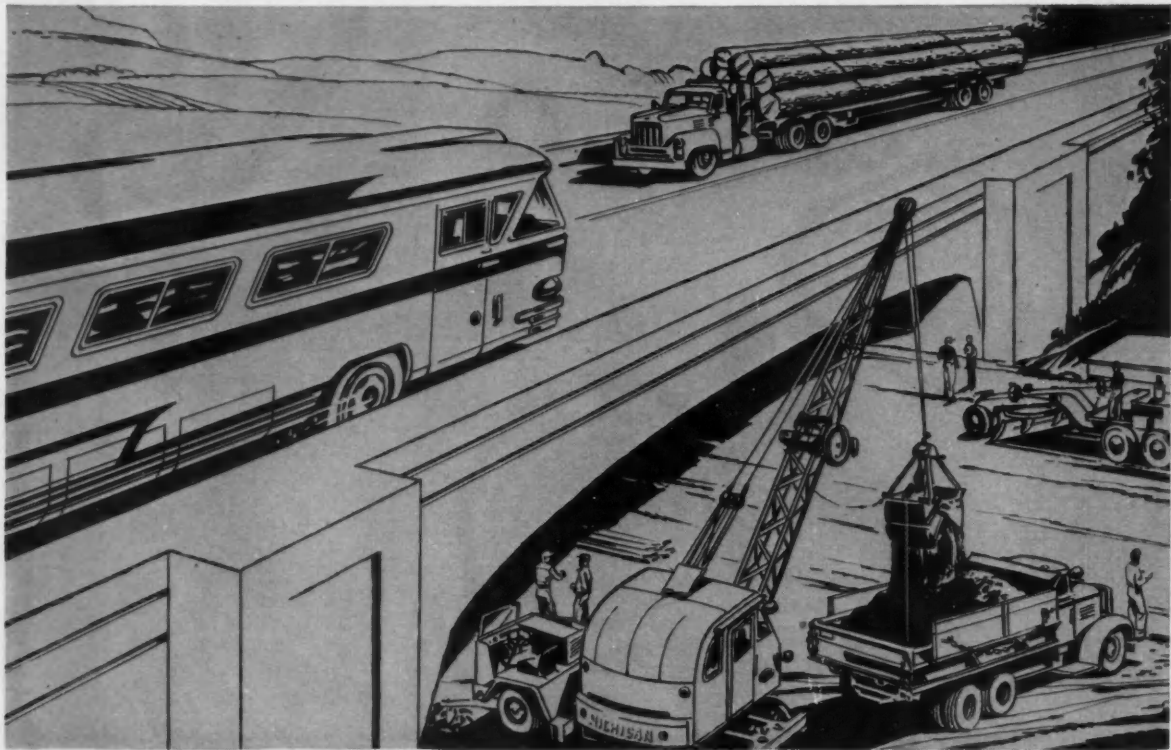
Your toughest filtration problems are within Purolator's experience.

*Filtration For Every Known Fluid*

**PUROLATOR**  
PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

## Important Announcement by Clark Equipment



### ... A New CLARK 5-Speed Synchronized Transmission



Here's news vital to operators and builders of heavy-duty equipment—trucks, coaches, crane-shovels, construction machinery.

This latest engineering triumph from power-train headquarters is entirely new in every detail; and is equipped with the Clark Split-Pin Synchronizer—proved dependable by millions of miles of heavy-duty operation

Two basic models—both 5-speed, synchronized in 2nd, 3rd, 4th, 5th

300 V—Nominal torque rating 350 lbs-ft

400 V—Nominal torque rating 450 lbs-ft

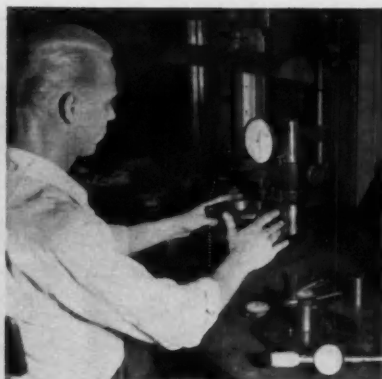
For full information mail your inquiry to Clark Equipment Company, Transmission Division, Jackson 27, Michigan.

Transmission Division  
**CLARK EQUIPMENT  
COMPANY**  
Falahee Road  
Jackson 5, Michigan

**CLARK®  
EQUIPMENT**



Accurate machining assures the smooth, cool operation of the Wagner Rotary Air Compressor. Close dimensions on all planes of the rotor eliminate vibration . . . permit compressor blades to function smoothly at high speeds



Accurate machining and gauge testing of the stator, as well as the rotor, also contributes to the rotary compressor's ability to operate for long periods of time without developing leaks or losing efficiency.



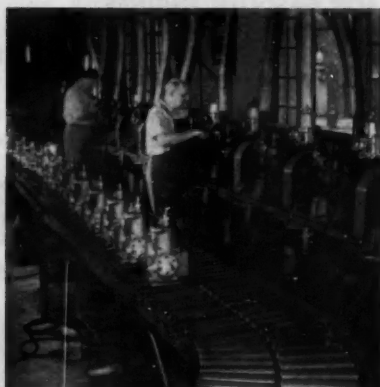
Compressor shafts are given the "cold box" treatment. When exposed to very low temperatures, the shaft diameter contracts. This altered shaft diameter allows proper insertion into a heated rotor to form a strong, composite unit.



Compressor rotors are subjected to high oven temperatures to expand rotor diameters. Shafts and rotors joined together under these extreme conditions resume their original relative size to create an extra strong assembly.



Assembled rotary compressors are hooked up to air lines and operating air pressure is applied for leakage tests. While holding pressure, entire compressor is submerged to determine whether any air is escaping.



Every Wagner Rotary Air Compressor is given a rigorous "run-in" test to determine its resistance to overheating and its overall performance. Running temperatures, vibration, noise and air output are carefully noted and analyzed.

## Rigid Quality Control assures uniform, safe performance and efficiency of all WAGNER ROTARY AIR COMPRESSORS

Wagner Rotary Air Compressors set exceptional records of safe performance, dependability, and air brake operating economy because of Wagner's "Quality Control" manufacturing program. Every Wagner Compressor must pass rigid inspection and tests before being released for shipment. That's why every user of a Wagner Rotary Air Compressor can rely on an adequate supply of air pressure

at all times, fast air recovery, long service life, and safer brakes. The vehicles you manufacture will be safer if they are equipped with Wagner Air Brake Systems—supplied with Wagner Rotary Air Compressors. Complete details on Wagner Air Brake Systems, Rotary Air Compressors, and other Wagner Air Brake Components are contained in Catalog KU-201. Write for your file copy today.



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6378 PLYMOUTH AVENUE, ST. LOUIS 14, MO., U. S. A.

LOCKHEED HYDRAULIC BRAKE PARTS and FLUID • NoRoL • CaMnX BRAKE LINING • AIR BRAKES • AIR HORNS • TACHOGRAPHS • ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES

# NEW

NEW

NEW

ESPECIALLY DESIGNED FOR TOP RING  
GROOVE PROTECTION IN PISTONS  
FOR GASOLINE ENGINES

AN ECONOMICAL METHOD WITH  
MINIMUM WEIGHT INCREASE

CAN BE APPLIED TO ANY TYPE  
ALUMINUM ALLOY PISTON

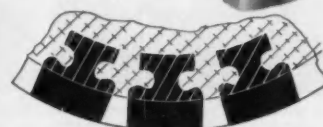


## PERMA-GROOVE\*

WITH SEGMENTAL STEEL TOP RING SECTION

Again, Zollner engineering leadership provides another great piston development to engine builders. The new Zollner "Perma-Groove" gives sensationally longer life to pistons and rings, prevents blow-by, minimizes oil consumption. The light weight segmental steel section incorporates high wear resistance in the top ring groove *plus* the advantage of cool operation. Designed especially for gasoline engine pistons, "Perma-Groove" is the quality, low-weight and low-cost companion to the popular "Bond-O-Loc" piston for Diesel engines. We suggest an immediate test of "Perma-Groove" advantages for your gasoline engine.

\*T. M. Reg. Pat. App. For



TOP RING SECTION



FRONT VIEW SECTION



CROSS SECTION

### OUTSTANDING ADVANTAGES OF ZOLLNER "PERMA-GROOVE" TOP RING SECTION

1. Individual steel segments eliminate continuous band expansion problem.
2. Segments securely locked to prevent radial movement.
3. Dovetailed edges keep steel segments securely in plane with groove.
4. 75% steel bearing area for wear resistance.
5. 25% aluminum bearing area for heat conductivity and cool operation.
6. Light in weight.

ADVANCED  
ENGINEERING  
PRECISION  
PRODUCTION  
COOPERATION  
WITH ENGINE  
BUILDERS

ZOLLNER  
**ZOLLNER**  
PISTONS

THE ORIGINAL EQUIPMENT PISTONS

ZOLLNER CORPORATION • Fort Wayne, Indiana

# NOW..3 new International V-8's

Now you have an even wider selection of economical International gasoline or LP-gas power for your products—three new power-packed, compact V-8's—the UV-549, UV-461, and the UV-401.

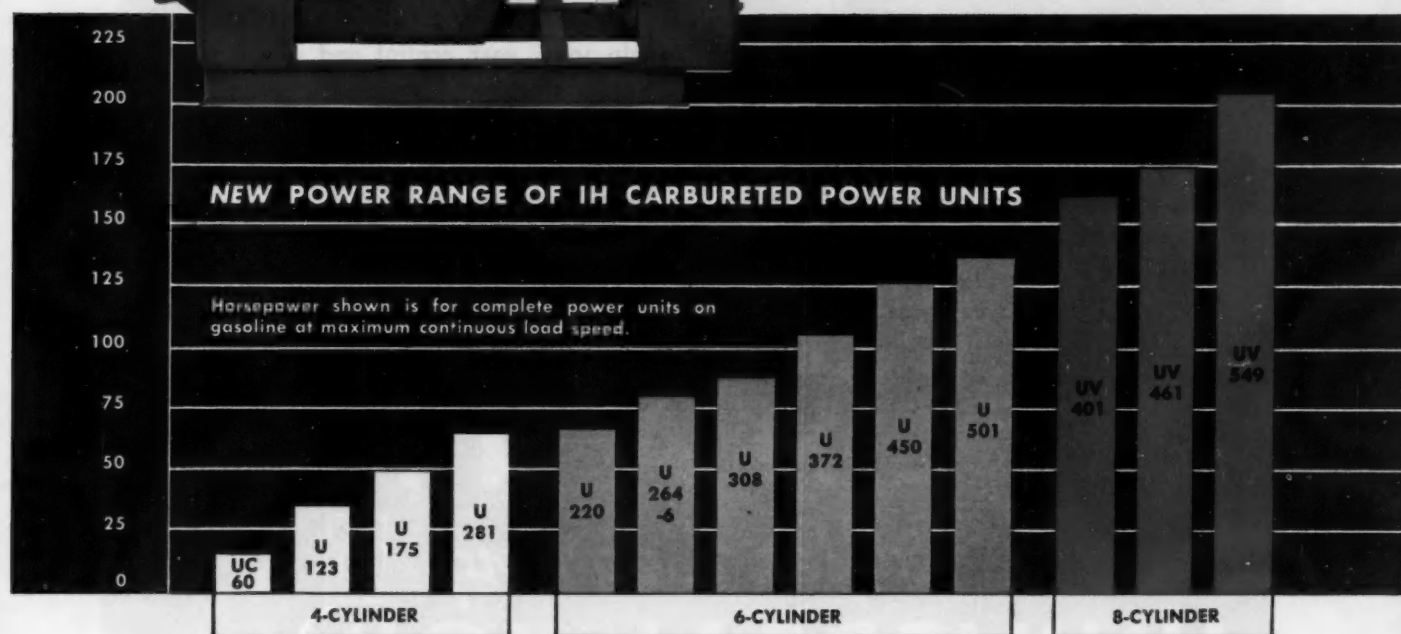
**NEW V-8 UV-549 POWER UNIT.** 208 net hp @ 2,600 rpm on gasoline, complete as shown. Not shown: UV-461 Power Unit—174 net hp @ 2,600 rpm, and the new UV-401 Power Unit—160 net hp @ 2,600 rpm.



These new models increase the International carbureted line to 13 models ranging from 16 to 208 hp on gasoline at continuous rated rpm, complete with regular accessories, fan and radiator. As stripped engines, they develop from 17 to 257 hp. LP-gas power is approximately the same as gasoline.

And just look at the standout V-8 features that help your customers cut operating costs: rigid, Y-shaped block; short-stroke, heavy-duty, cam-ground, 4-ring aluminum pistons; big, smooth-running, counterbalanced, tocco-hardened, 5-bearing crankshaft; large-area, long-life, tri-metal, replaceable bearings; combination full-flow, by-pass filter for long-life pressure lubrication; full-power, down-draft carburetion; oil cooler; and a 12-volt electrical system.

Our service to you will match the famous IH world-wide parts and service facilities that support these engines on the job—anywhere. Call in our experienced installation engineers or get pilot engine models for your research and testing before you specify. Your call or letter will get the special attention you need—fast.



**INTERNATIONAL<sup>®</sup>  
CONSTRUCTION  
EQUIPMENT**

International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill.

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors... Self-Propelled Scrapers... Crawler and Rubber-Tired Loaders... Off-Highway Haulers... Diesel and Carbureted Engines... Motor Trucks... Farm Tractors and Equipment.

# BALANCED



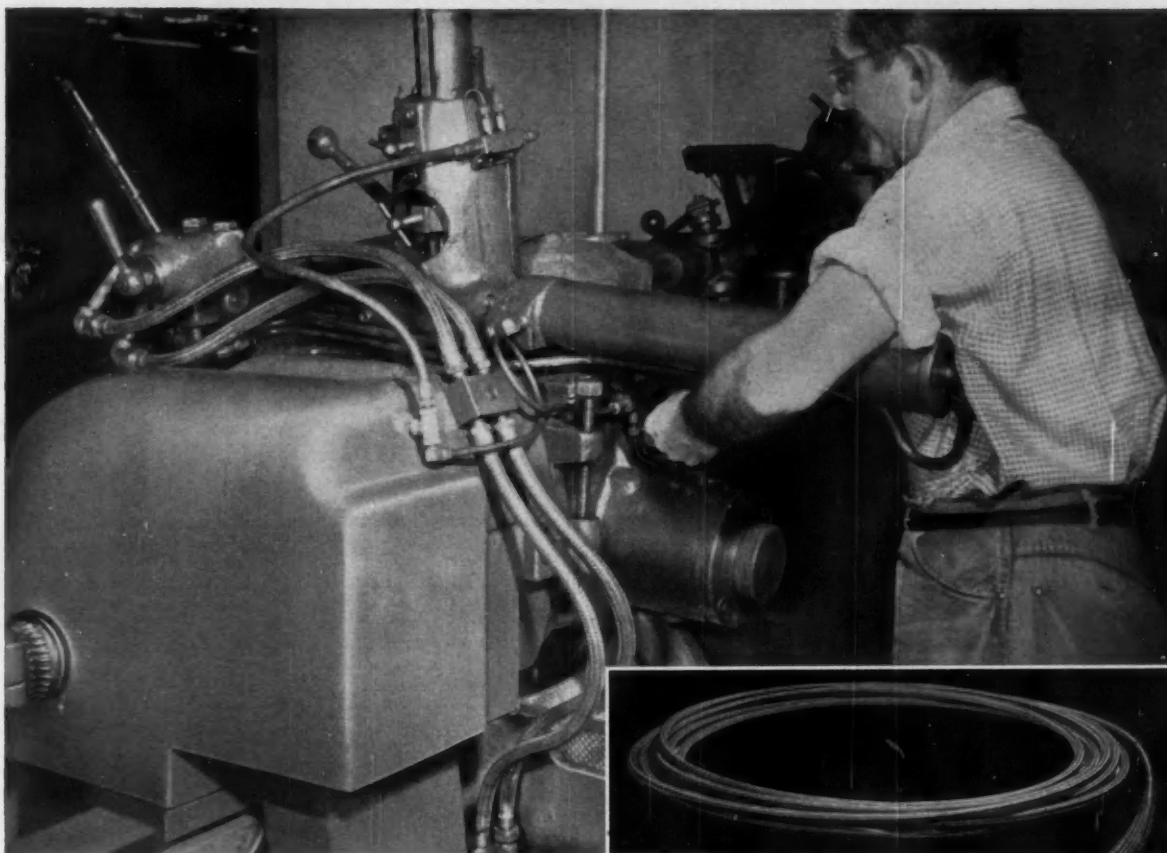
From the smallest helicopter to the largest bomber MECHANICS Roller Bearing UNIVERSAL JOINTS accuracy has met every aircraft need. Designs, metals, machining, tolerances, heat treating, hardening balancing and lubrication — all have been specifically adapted for aircraft precision. Let MECHANICS universal joint engineers

help solve your control and power transmission problems. Our new catalog, containing helpful universal joint engineering data and tracing kits, will be sent to engineers, upon request.

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## MECHANICS *Roller Bearing* UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery •  
Aircraft • Tanks • Busses and Industrial Equipment



## Where to use R/M FLEXIBLE THIN-WALL *Teflon* HOSE in automotive and aircraft applications

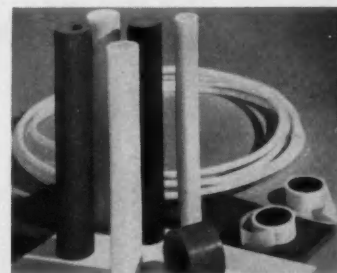
Wherever corrosive fluids, high mechanical stresses, or extreme ambient temperatures are involved in lines which must handle fuels, lubricating oil or hydraulic fluid, R/M Flexible Thin-Wall "Teflon" Hose provides easy solutions to difficult problems.

For example, take the precision centerless grinder above, which is used in the manufacture of critical aircraft components. Lines supplying its hydraulic infeed drive system must be flexible. They must handle cycling pressures in the range of 75 to 90 psi. R/M Flexible Thin-Wall "Teflon" Hose was found ideal for this troublesome application. It offers equal advantages in count-

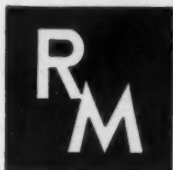
less difficult aircraft and automotive applications, for it serves continuously in temperatures ranging from -100 to 400°F without failure, lasts many times longer than similar hose of other materials, and is unaffected by aging or the highly corrosive agents it may encounter.

R/M Flexible Thin-Wall "Teflon" Hose, with wire-braided or rubber cover, is available through leading coupling manufacturers. We have pioneered in the development of products of "Teflon" for use in the automotive and aircraft fields. Write us for complete specifications on R/M "Teflon" products and name of nearest supplier.

\*A Du Pont trademark



Other R/M "Teflon" products for the automotive and aviation industries include rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; and Raylon, a mechanical grade of "Teflon" with many of the properties of virgin "Teflon." For details, call or write R/M.



## RAYBESTOS-MANHATTAN, INC.

### PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Manheim, Pa.; Paramount, Calif.; Bridgeport, Conn.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment  
Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

# 100-VOLT TRANSISTOR...

*New high power type  
available*



Typical Characteristics at 25° C		DT100
Maximum Collector Current		13 amps
Collector Voltage, Emitter Open		100 volts
Saturation Voltage (12 amps)		0.7 volts
Power Dissipation		55 watts
Thermal Gradient from Junction to Mounting Base		1.2° C/watt
Nominal Base Current $I_B$ ( $V_{EC} = -2$ volts, $I_C = -1.2$ amp.)		-19 ma
Distortion (Class A <sub>1</sub> , 10 watts)		5%

## DELCO HIGH POWER TRANSISTORS

The electronics industry asked for a transistor to handle higher voltage—and here it is—Delco Radio's DT100 with maximum collector diode voltage of 100 volts. This is the highest yet, and it paves the way for a wide range of new applications. The new DT100 is an alloy junction germanium PNP transistor—normalized to retain its performance characteristics regardless of age. You can depend on the uniformity, reliability and high current handling capacity of the DT100, just as you have in the past on all of Delco Radio's High Power transistors. Write today for complete engineering data.

### DELCO RADIO

Division of General Motors  
Kokomo, Indiana



Better Things for Better Living  
through Chemistry

## AUTOMOTIVE ENGINEERING

LATEST PROPERTY AND APPLICATION DATA ON

**ZYTEL®**

nylon  
resin

# NEWS

## Now—versatile Du Pont ZYTEL® nylon resin used in a wide variety of improved auto parts

The use of Du Pont ZYTEL for structural and mechanical parts is constantly expanding. The moldability of ZYTEL makes it a natural for use where millions of units are required. Its high strength in combination with other high-grade properties is especially valuable in the automotive industry.

As an example, ZYTEL offers a combination of toughness, abrasion resistance and hardness for making automotive gears. Another important asset of ZYTEL as a gear material is its resilience. This is the ability of the material to yield under pressure and return to its original state when pressure is released. This property plus its low coefficient of friction permits ZYTEL to outperform steel at ordinary temperatures. Tooth errors which are usually destructive, such as pitch variations, profile error and excessive runout, are minimized at the instant of engagement.

ZYTEL nylon resin is extremely wear-resistant. Both gears and sleeve bearings of ZYTEL tested in the presence of abrasive materials such as sand have outworn metal components by far. Parts of ZYTEL require little or no lubrication.

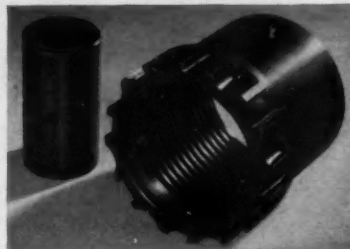
A valuable characteristic of ZYTEL

is its resistance to petroleum lubricants. It will not swell or deteriorate in contact with oils, greases, hydraulic fluids or gasoline. Designers can specify lubricated gears, bearings and bushings of ZYTEL without fear of failure.

Frequently, a single part of ZYTEL can replace a number of metal parts, thus eliminating machining and assembly operations. For example, a single speedometer part includes a worm gear, pinion and four different shaft diameters, all molded in one. The economy of such parts is obvious.

Parts of ZYTEL can be molded directly onto metal pieces. A combination often used is a gear of ZYTEL with an imbedded metal shaft. ZYTEL is rated for intermittent operation up to 250°F. For continuous operation at such elevated temperature, heat-stabilized grades are available. For decorative uses, it is available in rich, deep colors, including metallics.

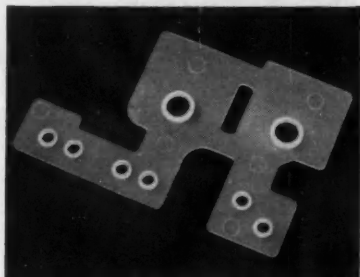
It may well be possible to make your sub-assemblies better at lower cost by using durable parts of Du Pont ZYTEL—as you will be able to judge if you send for the informative material we have made available. Get the facts by using the coupon below.



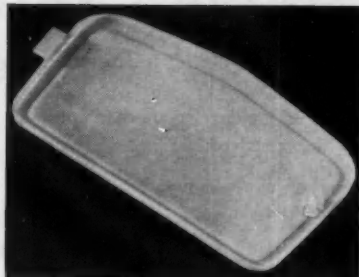
Eight of these large main hangar bushings made of ZYTEL are used per trailer; sixteen of the smaller shackle bushings go into the trailer's torsion-bar suspension system.



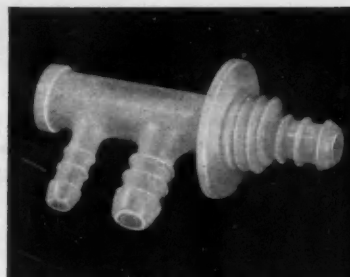
Anti-rattle plate is extruded from ZYTEL 42. Thin, uniform sections of ZYTEL nylon resin absorb shock and vibration without damage. (Extruded by Anchor Plastics Co., Inc., Long Island, N. Y.)



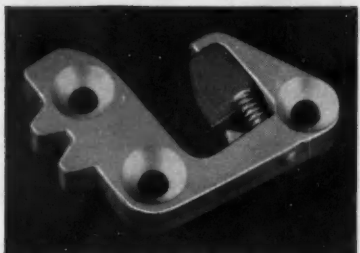
Voltage-regulator base made of ZYTEL provides good electrical insulation... is highly resistant to cracking under mechanical stresses.



Thin sections of ZYTEL are translucent, yet strong and flexible. This lens is heat-resistant. Molded projections simplify attachment.



Smooth, accurate moldings such as this windshield washer T-connection reduce cost of sub-assemblies. Note integral mounting threads.



Hard, smooth door-lock wedge of ZYTEL needs no oiling. Spring-loaded, it operates efficiently due to low inertia... resists shocks.

### SEND FOR INFORMATION

For additional property and application data on Du Pont ZYTEL nylon resin, clip and mail this coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.  
Room 511, Du Pont Building, Wilmington 98, Delaware  
Please send me more information on Du Pont ZYTEL nylon resin.  
I am interested in evaluating this material for \_\_\_\_\_

Name \_\_\_\_\_

Company \_\_\_\_\_ Position \_\_\_\_\_

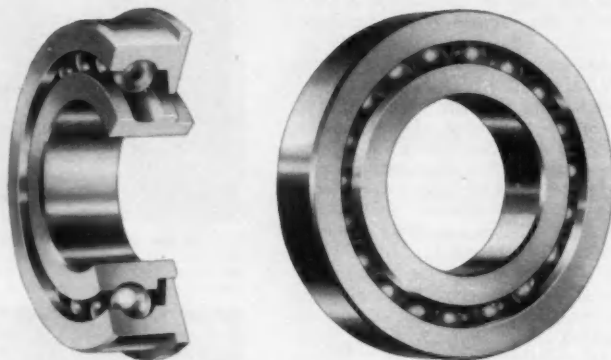
Street \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_

Type of Business \_\_\_\_\_

IN CANADA: Du Pont Company of Canada (1956) Limited, P. O. Box 680, Montreal, Quebec

# HEIM INTRODUCES THE NEWEST IDEA IN BALL BEARINGS without insertion grooves or inserts



A most unusual, NEW concept in ball bearing design . . .

Here is a commercial ball bearing with solid, unbroken machined inner and outer raceways, yet with a full complement of balls.

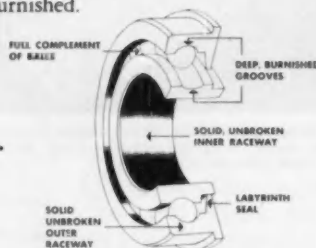
It has deep, burnished ball grooves that are deep carburized and hardened. The revolutionary and radically new method of manufacture permits assembly of these ball bearings in a way that borders on the mysterious and challenges the imagination.

Radial and axial load capacities are increased because of the raceway construction, resulting in longer bearing life.

Unibal Ball Bearings can be furnished in single row, double row and flanged types; to close tolerances on bore and outside diameter; and with controlled radial and axial play.

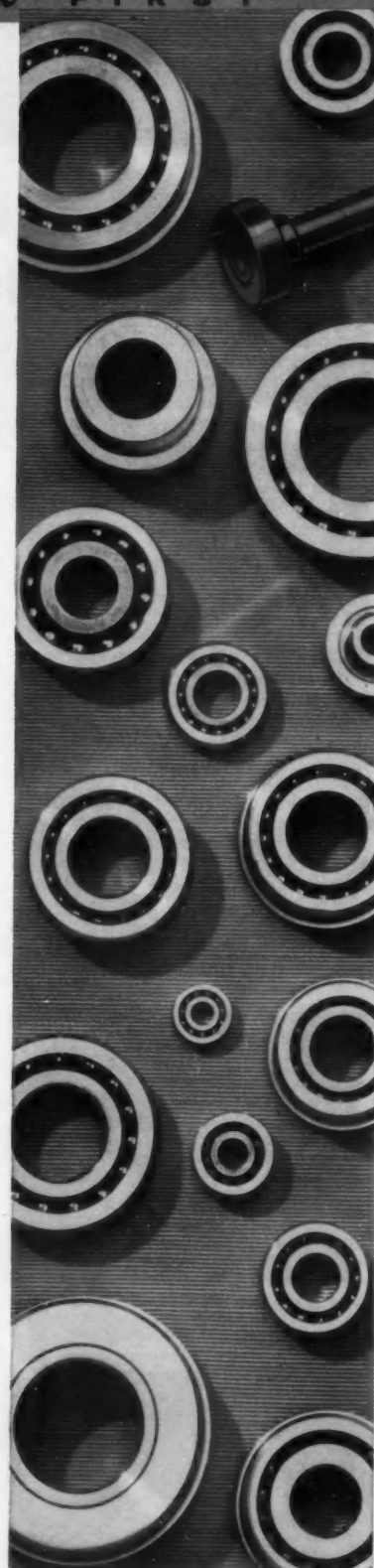
Close, integral labyrinth seals on one or both sides are another unusual feature, where sealed type bearings are required. Extremely narrow widths and small diameters can be furnished.

## NOTE THIS CONSTRUCTION . . .



*Special circular with load ratings and dimensions on the new Unibal Ball Bearings is available.*

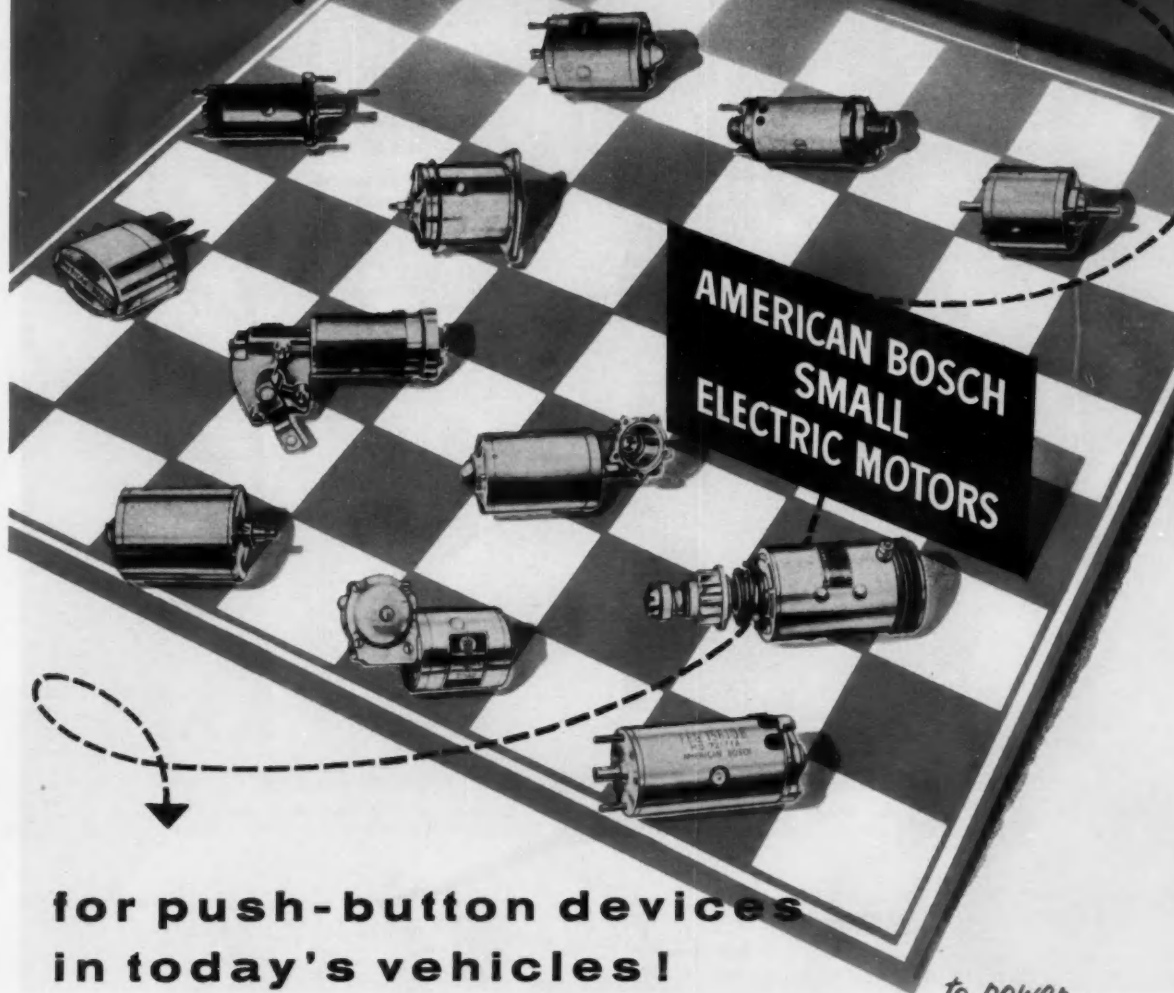
HEIM also makes the Unibal Spherical Bearing Rod End. Send for complete catalog of all Heim bearings. Write direct or see your local bearing distributor.



THE HEIM COMPANY

Fairfield, Connecticut

*plan your next move*



## for push-button devices in today's vehicles!

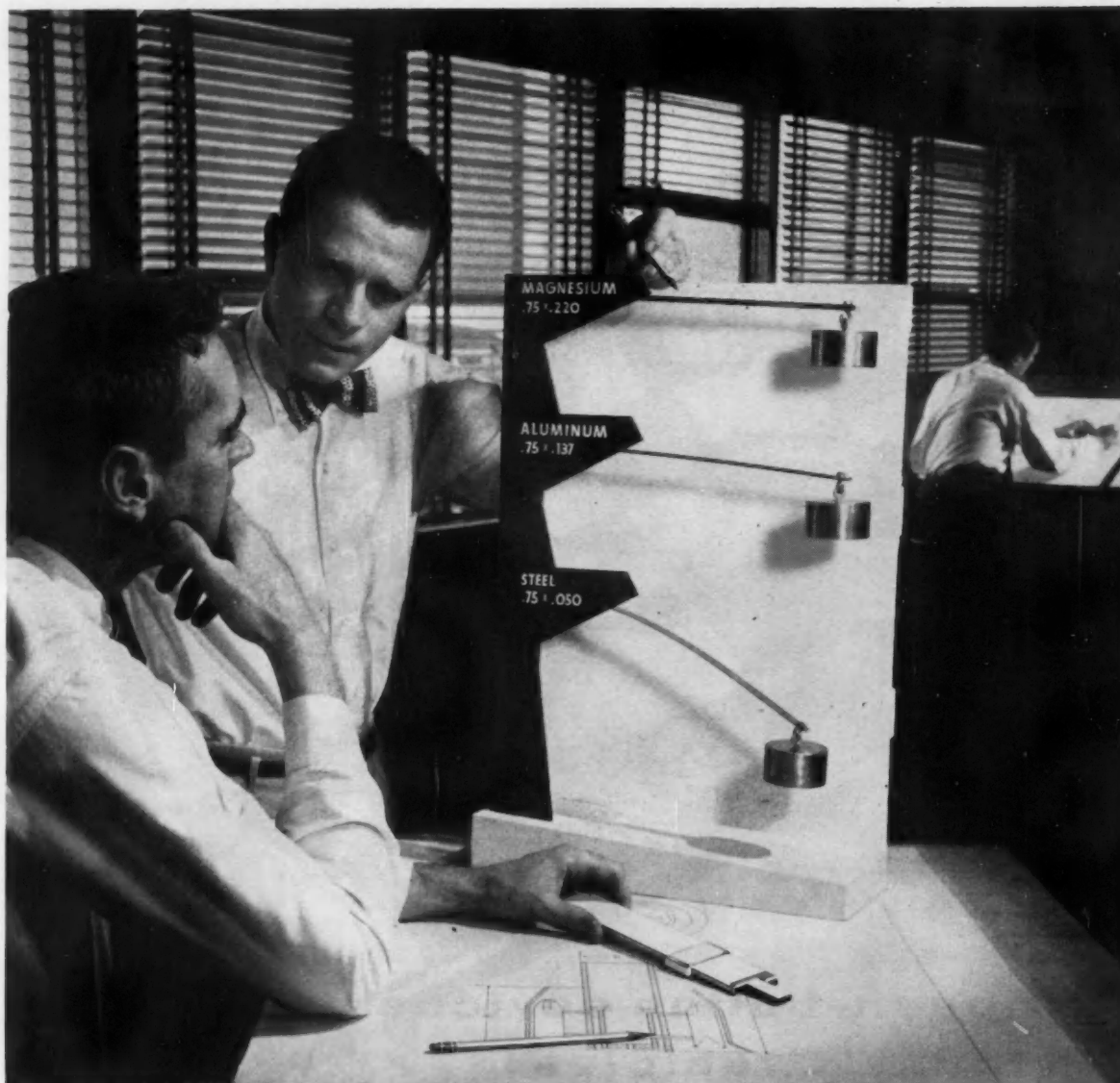
You can plan effectively with this big variety of small, high torque Electric Motors... they're the power behind today's push-button devices in modern vehicles and in wide use as original equipment. Imaginative American Bosch designing and sound electrical engineering coordinate to provide you with these dependable, compact, decimal horsepower motors. If you have one or a number of small motor requirements in your plans, put the problem up to American Bosch, Springfield 7, Mass. A Division of American Bosch Arma Corporation.

*to power—*

WINDSHIELD WIPERS  
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HEATERS • STARTERS  
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FUEL PUMPS • ANTENNAE  
AXLE MECHANISMS  
TRANSMISSION SELECTORS  
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REAR DECKS • PACKAGE TRAYS

# AMERICAN BOSCH





## Rigidity! At equal weight, magnesium is 18 times stiffer than steel

Magnesium's unique combination of strength and light weight gives it some outstanding abilities as a structural metal. Take rigidity, for example. A magnesium bar has 22% the stiffness of a steel bar of the same dimensions.

But stiffness increases as the cube of section thickness. So, if thickness of the magnesium is increased to twice that of the steel, the magnesium bar will be over 70% more rigid—yet weigh only half as much. And if thickness is further increased until the bars are of equal weight, the magnesium bar will be 1878%—or over 18 times—more rigid!

Similarly, a magnesium bar of equal rigidity to an aluminum bar will weigh only 75% as much as the aluminum bar. At equal weight, the magnesium bar will be over twice as stiff.

From these facts it's easy to see that magnesium can do a structural job equal to or better than steel and aluminum—and with appreciable savings in weight—whenever it's practical to increase section thickness. For more information contact the nearest Dow sales office or write to us. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Department MA-1402D-1.

YOU CAN DEPEND ON

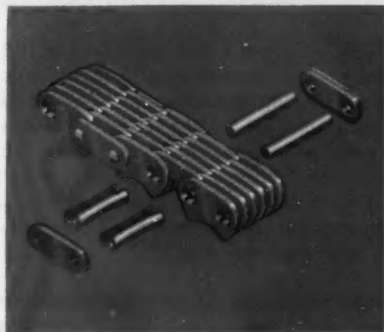




More than 80,000,000 durable Morse Timing Chains have been used by the auto industry. Now specified as original equipment for 3 out

of 4 passenger cars, Morse Timing Chains give car owners steady, reliable service—operate quietly and smoothly, with positive timing.

## WHY 3 OUT OF EVERY 4 CARS ARE EQUIPPED WITH MORSE TIMING CHAINS



This new Morse Timing Chain, above, designed to meet the needs of higher horsepower 1958 cars, features spring-bushing joint construction for longer service, smoother and quieter operation. The new bushing cuts joint vibration by reducing tendency to "whip", provides for take-up of slack, and serves as a damping device to minimize noise. Ask for Catalog C80-51.

Chances are your new car will have a Morse Timing Chain. For sound reasons, too. Morse Timing Chains are precision-built—like fine watches—to give car owners longer service life and freedom from maintenance worries.

*In Morse Timing Chains, sure dependability is built right in!*

If you have a timing chain problem, original equipment or replacement, it will pay you to get in touch with Morse. For full information—and ready engineering help—phone, wire, or write **MORSE CHAIN COMPANY, DETROIT, MICHIGAN; ITHACA, NEW YORK**. Export Sales: Borg-Warner International, Chicago 3, Ill.

**SERVING THE AUTOMOTIVE  
INDUSTRY FOR OVER 55 YEARS**

# MORSE



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For whatever you make . . .

# **N-A-X<sup>®</sup> FINEGRAIN STEEL**

## **DELIVERS STRENGTH**

## **WITH TOUGHNESS**



No more dramatic test of a steel's combined strength and toughness could be devised than the kind of job performance which Caterpillar Tractor Co. builds into its products.

As Caterpillar equipment literally moves the earth, bulldozer blade surfaces and scraper bowl bottoms must stand up to gruelling punishment. In these critical components, Caterpillar standards for steel are of the highest. N-A-X FINEGRAIN steel meets those standards with the right combination of strength with toughness.

And to this manufacturing operation, like so many others, N-A-X FINEGRAIN brings other important benefits as well. For example, the excellent weldability of N-A-X FINEGRAIN steel makes it exceptionally adaptable to Caterpillar's exacting requirements.

**Review these salient advantages for your job:** N-A-X FINEGRAIN steel, compared with carbon structural grades,

is approximately 50% stronger • has high fatigue life with great toughness • is cold formed readily into difficult stampings • is stable against aging • has greater resistance to abrasion • is readily welded by any process • offers greater paint adhesion • polishes to a high luster at minimum cost. And the physical properties of N-A-X FINEGRAIN are inherent in the "as rolled" condition. N-A-X FINEGRAIN's resistance to normal atmospheric corrosion is twice that of carbon structural steel.

**NOTE:** Where greater resistance to extreme atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE is recommended.

For whatever you make, from tractors to pressure cylinders, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products.



*This bowl bottom assembly of the Caterpillar No. 470 Scraper requires numerous individual welding operations in its manufacture. Not only the parent metal, but the welds themselves, must have strength with toughness. Again, N-A-X FINEGRAIN steel proves its excellent weldability.*



*Here Caterpillar Earthmoving Equipment pushes America's great highway program forward. A Cat® DW 21 and matching No. 470 Scraper lead the way. The Cat DW 21 is assisted by a Caterpillar-built crawler Tractor.*



N-A-X Alloy Division, Dept. F-9

**GREAT LAKES STEEL CORPORATION**

Detroit 29, Michigan • Division of



**N-A-X Alloy Div., Dept. F-9**

**Great Lakes Steel Corp., Detroit 29, Michigan**

- ☐ Please send me technical data on N-A-X FINEGRAIN steel.  
☐ Please have your representative contact me.

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**ENJAY BUTYL**

*all-weather wonder rubber* **OFFERS TRIPLE VALUE**

Performance! Versatility! Economy! In all three, Enjay Butyl is the world's outstanding rubber value. In laboratory tests, and in a wide variety of automotive applications, Enjay Butyl has demonstrated its great strength and outstanding resistance to weather, impact and abrasion, moisture and aging . . . properties that are helping to improve the performance of many of today's new cars.

Windshield weatherstrips, convertible tops, axle bumpers, radiator hoses . . . in more than 100 places on today's new cars, Enjay Butyl out-performs and out-lasts *all other* types of rubber formerly used, synthetic or natural. *Low-in-cost* and *immediately available* in regular and non-staining grades for white and colored parts, this truly wonder rubber may well be able to cut costs and improve performance in still more automotive parts. For further information, and for expert technical assistance, contact the Enjay Company.

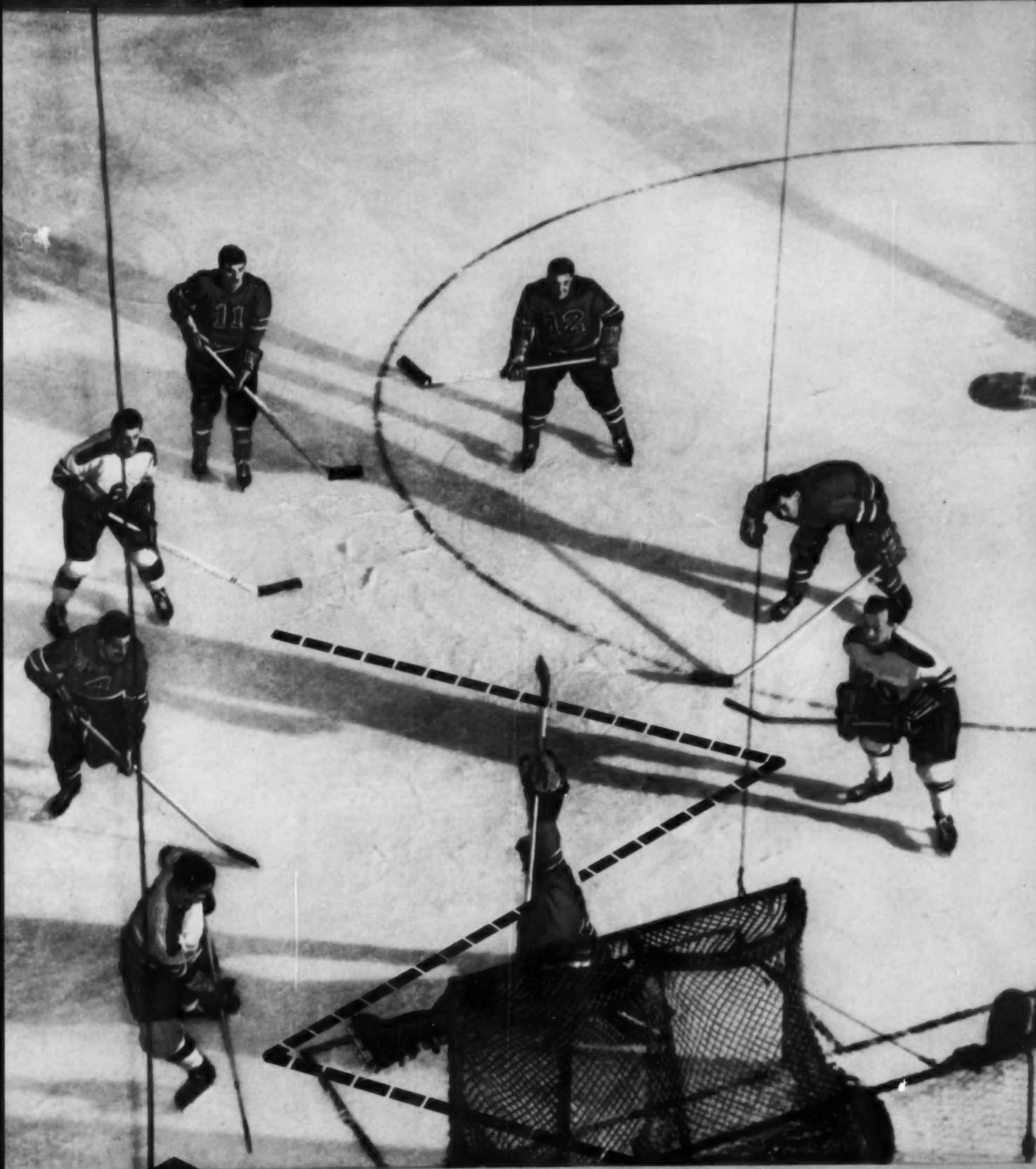


*Pioneer in Petrochemicals*

**ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.**  
Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa



Enjay Butyl is the greatest rubber value in the world . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.



It takes the right system .....

It takes the right system to make the score . . .



Their famous systems helped make the win! In hockey: Olson to Gordon to Glover *and goal!* In baseball: Tinker to Evers to Chance *and out!* In football: Knute Rockne's famous Box Shift scored touchdowns!

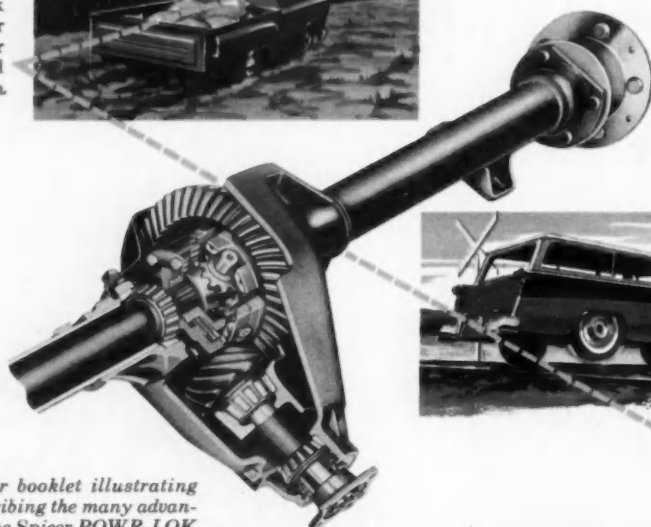
Their secret was keeping their power flexible . . . passing it from point to point with flashing speed to meet ever-shifting problems.

That is the secret of the Spicer POWER-LOK Differential. POWER-LOK automatically delivers the greatest driving force to the rear wheel that has the best gripping traction. It instantly shifts this driving power from one wheel to another, as the tractive conditions under each wheel change, to assure pulling power like this:



POWER-LOK ends slipping on ice or wet hills and pavements if either rear wheel can catch hold.

POWER-LOK ends sliding, grinding and getting stuck in mud or sand if either rear wheel can catch hold.



POWER-LOK stops "wild wheel" hop and spin on rough, bumpy roads, ending dangerous car swerve and unbalance.

Write for booklet illustrating and describing the many advantages of the Spicer POWER-LOK Differential.

**DANA CORPORATION**  
Toledo 1, Ohio

**DANA PRODUCTS Serve Many Fields:**

**AUTOMOTIVE:** Transmissions, Universal Joints, Propeller Shafts, Axles, Power-Lok Differentials, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Clutches, Frames, Forgings, Stampings.

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**RAILROAD:** Transmissions, Universal Joints, Propeller Shafts, Generator Drives, Rail Car Drives, Pressed Steel Parts, Traction Motor Drives, Forgings, Stampings.

**AGRICULTURE:** Universal Joints, Propeller Shafts, Axles, Power Take-Offs, Power Take-Off Joints, Clutches, Forgings, Stampings.

**MARINE:** Universal Joints, Propeller Shafts, Gear Boxes, Forgings, Stampings.

Many of these products manufactured in Canada by Hayes Steel Products Limited, Merriton, Ontario





New anti-smog muffler on a Los Angeles bus. Unit operates on the principle of self-contained combustion of unburned fuel carryover in exhaust. The high heat and oxidation

resistance of nickel-containing stainless steel helped make the design practical. Sold by Clayton Clearair Muffler Company, 403 West 8th St., Los Angeles 14, Calif.

## New anti-smog muffler made of Type 321 Stainless to withstand 1300°F.

The Clearair Muffler is actually a muffler with a 1300°F. afterburner. Selecting materials posed a two-fold problem.

First, all inner parts of the unit — tubes, burner cone, inner shell and the like — needed high heat and oxidation resistance for the 1300°F. temperatures developed in the afterburner.

Second, because most of the components were sheet-metal stampings . . . or formed and welded sub-assemblies, the designers needed a material

that formed easily . . . welded easily.

### **Type 321, a stabilized stainless steel, does the job on both counts.**


Type 321 austenitic nickel-chromium stainless steel provides the necessary heat and oxidation resistance for parts subject to 1300°F. temperatures. It also provides high resistance to corrosive gases.

Type 321 solves the production problems too. It forms easily. It welds easily. Spot, seam and Heliarc techniques are all used successfully

by Clayton Manufacturing Co. in fabricating the unit.

If you have a difficult design problem, chances are one of many nickel-containing stainless steels is the answer for you too. For detailed information on how to make the right selection, send for "Stainless Steel In Product Design." It covers properties, forms available, applications and other valuable data.

**The INTERNATIONAL NICKEL COMPANY, Inc.**

67 Wall Street  New York 5, N. Y.

# INCO NICKEL

NICKEL ALLOYS PERFORM BETTER LONGER

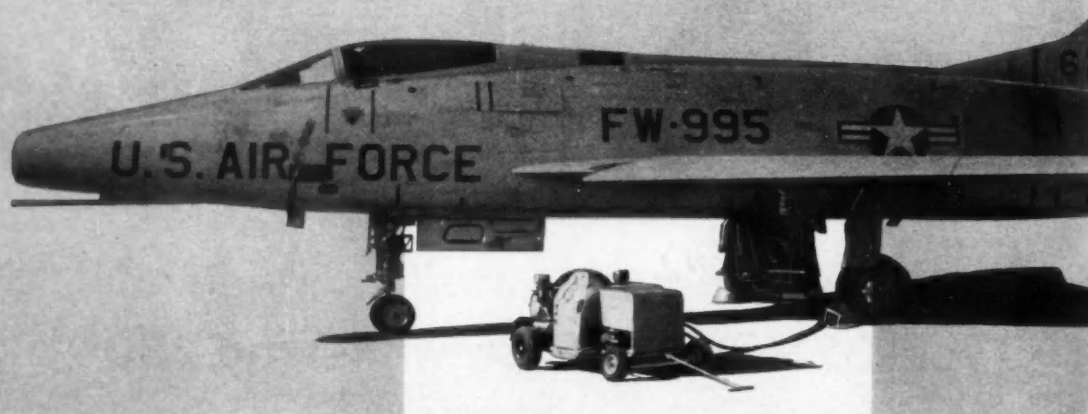


## DEMONSTRATES NEW HYDRAULIC STARTER PACKAGE

As a part of its jet engine hydraulic starting system evaluation program, Vickers Incorporated recently demonstrated the ability of its starter package to start Century Series fighters. Acceleration to ground idle speed of the J-57 turbojet engine, installed in a production North American F-100D Super Sabre, was accomplished in times comparable to other known starting means...using only 50 horsepower, prime mover power.

Consisting basically of production Vickers aircraft hydraulic components...performance-proven on almost all existing U.S. military and commercial aircraft...the Vickers starting system offers substantial savings in weight, size, and cost — both initial and maintenance — over other known means. Available as either a ground mobile unit or an aircraft-installed airborne version, the Vickers starter package is capable of dual function. After engine starting, the hydraulic starter motor can serve as an engine-driven pump for aircraft auxiliary power requirements in the airborne version.

For further information regarding Vickers hydraulic starting systems, write for illustrated brochure SE-94a. Also, your nearest Vickers representative can show you the many system combinations available to meet your specific needs.



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DIVISION OF SPERRY RAND CORPORATION

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

**NOW...FROM**

**WARNER**



Model shown is for 8 to 12 hp  
self-propelled vehicles

## **COMPLETE POWER TRAIN ASSEMBLIES**

One source, single responsibility, integrated engineering, uniform quality and dependability, lower cost . . . these are important advantages you get when Warner supplies your small-vehicle power train requirements.

The typical assembly illustrated includes clutch, 3-speed transmission, bevel gear right angle drive and brake, all in one compact assembly. And all engineered and fabricated by Warner to exacting quality and performance standards.

Warner's design experience, unique engineering skills and specialized manufacturing facilities are your assurance of real help with your assembly problems. And you can make us prove it, *without cost or obligation*. Write—now—for full information.



**WARNER**  
AUTOMOTIVE PARTS DIVISION

BORG-WARNER CORPORATION, Auburn, Indiana

*Products of Experience*

GEAR BOXES • TRANSMISSION GEARS • RING  
GEARS AND PINIONS • DIFFERENTIAL PARTS AND  
ASSEMBLIES • SPLINED SHAFTS

# MIDLAND

## Air Compressor Protects You Against Oil Passage, Carbon . . . Provides Dependable, Trouble-Free Service!

For air braking systems on trucks, trailers, or buses — or wherever compressed air is required — you'll get better, longer, *more dependable* performance from Midland Compressors.

Midland Compressors reduce oil passage to a minimum . . . so, no carbon, no headaches . . . In short, Midland Air Compressors have all the advantages anyone who needs compressed air could hope to have in *one* product: (1) less power re-

quired per cubic foot of air; (2) no oil-passing worries; (3) cooler operation; (4) governor mounted on compressor itself for simplicity; (5) lighter weight; (6) so easy to install; (7) maintenance a cinch (only 1 simple adjustment to control reservoir pressure range) . . . Man, what a compressor! Your nearest Midland Distributor (they're everywhere) will be happy to give you the complete story . . . or you may contact the factory direct.

### THE MIDLAND STEEL PRODUCTS COMPANY

Owosso Division



Owosso, Michigan

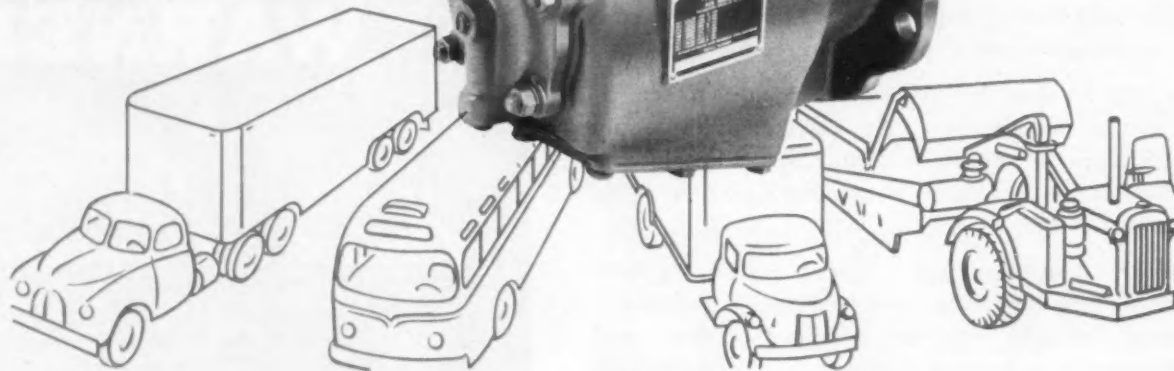
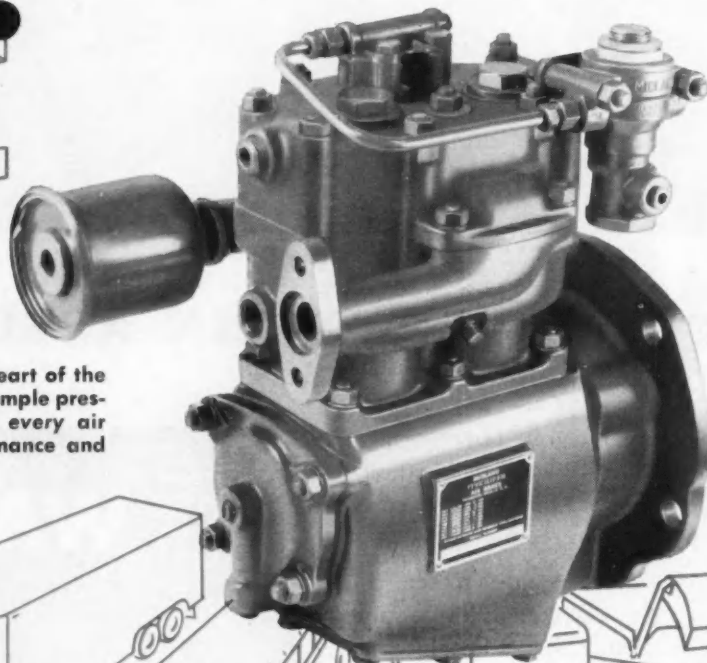


Export Department: 38 Pearl Street, New York, N.Y.



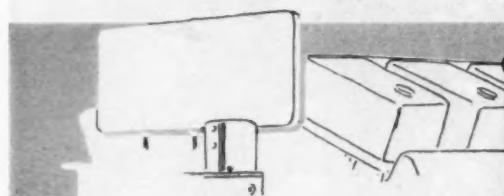
STEEL PRODUCTS CO.

**BIG MODEL 12**—the Heart of the air system—provides ample pressure and volume for every air need. Rugged performance and dependability!



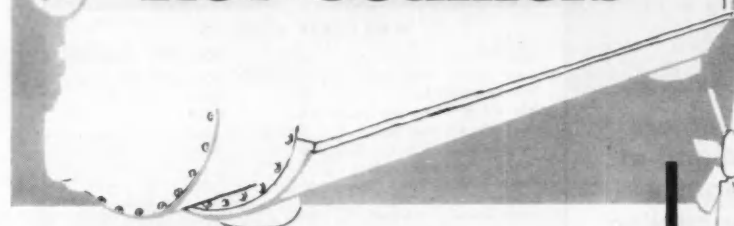
# NEW

## Tachometer Take-Off



**...for**

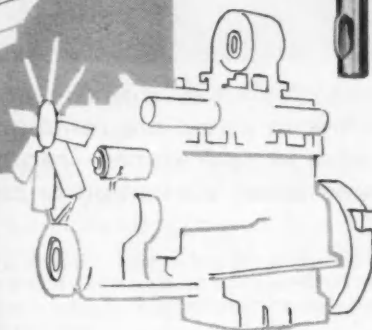
## VEEDER-ROOT Rev-Counters



With this new attachment, Veeder-Root Rev-Counters can be installed on any engine having a tachometer take-off in a position which is readily accessible for easy reading. Take-off can be furnished to suit average engine-speed.

So now you can make it easier than ever for your customers to see that your product is performing up to its guarantee . . . to see when routine maintenance is coming due, and whether servicing is needed.

You can count on Veeder-Root to figure out how to engineer these adaptable Rev-Counters into *your* products . . . not only engines, but generators, compressors, heaters, refrigerators, and what have you? Write:



*Everyone...  
Can Count on*

## VEEDER-ROOT

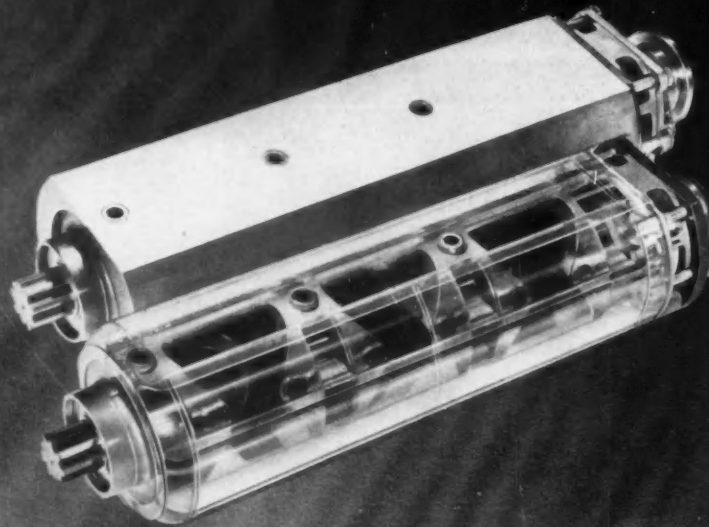
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Offices and Agents in Principal Cities

# Power Actuation at +1000°F



**AiResearch Cam-Piston Air Motors**  
function with complete reliability at  
extreme temperatures—require  
no conventional lubrication or cooling

SPECIFICATIONS			
Model Numbers	CM-710 *(illustrated)	CM-350	CM-160
Total Length (in.)	13.3	11.8	9.7
Min. Height (in.)	3.1	2.9	2.5
Max. Dia. Envelope (in.)	4.0	3.2	2.5
Weight (lb.)	22	15.5	7.5
Output at 200 psig supply pressure and 1200 rpm (hp)	18.5	9.1	4.2
Starting Torque at 200 psig supply pressure (inch-pounds)	1800	890	400

Here are air motors that operate dependably far beyond the temperature limits of electronic and hydraulic units.

Using bleed air as a source of energy, the output of the air motor is almost linear with inlet pressure, allowing maximum efficiency through a wide range of operating conditions. High horsepower and torque to weight ratios are obtained by displacement volume per revolution exceed-

ing the overall volume of the motor.

Motor acceleration is extremely fast—less than .05 second in most applications. Low rotating speeds—from 100 rpm to 2500 rpm—make gear reduction unnecessary and minimize problems of over-speed control, rotational stresses and wear.

Flexibility of the basic design allows for a wide range of motor sizes—from less than 1 hp up to 300 hp—depending on the available pressure

supply. Length vs. diameter shape can be changed by varying the number of pistons and/or the piston diameter and stroke.

When coupled with a ball screw which may retract within the full length of the motor shaft, the cam-piston air motor has wide application as a compact, high-performance linear actuator in high temperature pneumatic power control systems.

Your inquiries are invited.



• Outstanding opportunities for qualified engineers

**AiResearch Manufacturing Divisions**

Los Angeles 45, California...Phoenix, Arizona

Designers and manufacturers of aircraft and missile systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS  
CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS

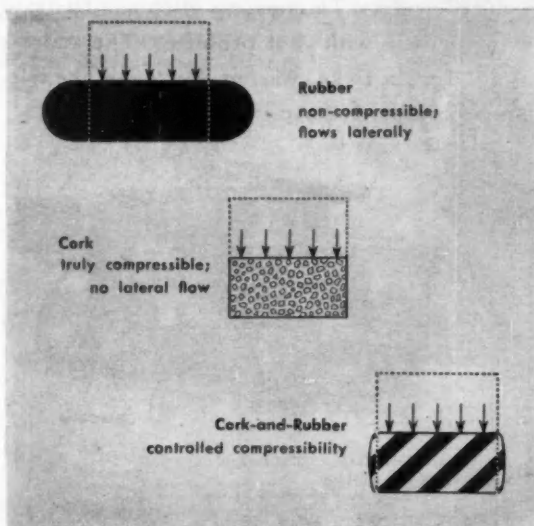
# How to cut the cost of O-rings

Lathe-cut, compressible cork-and-rubber rings often can reduce your O-ring costs substantially. At the same time, they may effect savings in machining time and inventory costs. Here's why:

Molded rubber O-rings are incompressible and therefore must be made to very close tolerances to allow perfect fit between the flanges. An O-ring too small in cross-section will not seal effectively . . . and an oversize O-ring will prevent flange contact.

Cork-and-rubber compositions, on the other hand, combine the compressibility of cork with the non-compressibility of straight rubber compounds. This compressibility can be controlled and compositions produced which are nearly as compressible as cork, or almost as incompressible as rubber. The percent of compression for cork-and-rubber rings may range, therefore, from 20% to 33%.

In some applications, the wider tolerances permissible with compressible lathe-cut rings may effect savings in machining time. In other cases, it may be possible to reduce inventories because one size of



cork-and-rubber ring may work where two or more rubber O-ring sizes might otherwise be required.

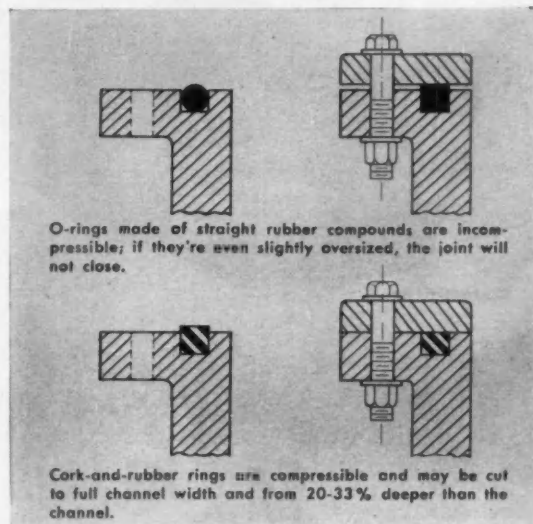
Armstrong Cork-and-Rubber Rings can be cut to fit existing channel dimensions (from  $\frac{3}{8}$ " to 20" I.D.), with no change required in channel size or design.

## Imperviousness

All lathe-cut Armstrong cork-and-rubber compositions are impervious. Their rubber binder encloses each cork particle in a continuous matrix. Cork-and-rubber can be used to seal high internal pressures. The upper and lower temperature limits vary with the different compositions and with the fluids to which they are exposed. In most cases, continuous operating temperatures should not exceed 300° F.

## Solvent resistance

The solvent resistance of cork-and-rubber compositions is comparable to straight synthetic rubbers of corresponding base polymers. For example, cork-and-chloroprene-type synthetic rubber is normally used with lubricating oils, and for general purpose applications where some swell is desired or can be



tolerated. Cork-and-nitrile-type synthetic rubber provides good gasoline and aromatic-solvent resistance and has less tendency to swell or stick on metal surfaces. Cork-and-styrene-type synthetic rubber compounds, however, have very limited solvent resistance and should not be used for these purposes.

## SEND FOR 24-PAGE GASKET MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy to Armstrong Cork Company, Industrial Div., 7111 Durham St., Lancaster, Pa. For information on all Armstrong Gasket Materials, see Sweet's product design file.



**Armstrong**  
**GASKET MATERIALS**

... used wherever performance counts



International



Diamond T

## The BIG JOBS count on Thompson linkage, too



Caterpillar



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Euclid

Four Wheel Drive

**S**TEERING linkage, engineered and manufactured by Thompson Products' Michigan Division, isn't only used on leading passenger cars. Heavy duty vehicle manufacturers count on Thompson too, as you can see from some of the big jobs above. All of them are equipped with Thompson chassis parts.

Thompson is continually being called upon by the automobile, truck, farm machinery and off-the-road vehicle manufacturers to come up with new ideas and new manufacturing. Why don't you call or write Thompson's Michigan Division now for help with your problems. The address is 34201 Van Dyke, Warren, Michigan; the telephone number Jefferson 9-5500.

You can count on



**Thompson Products**

Michigan Division: Warren and Portland

another result of A-MP'S CREATIVE APPROACH . . .

## *Fastin-Faston\* Harness Connectors*

*for simultaneous engagement*

*of multiple circuits*

*in appliance and automotive wiring*

A new highly versatile assembly unit that makes one operation out of many. Saves time, trouble, money.

Simplifies such operations as the connecting of wall switches to built-in ranges . . . top with bottom circuits in clothes washer . . . front and back assemblies to car electrical systems.

Uses quick, easy-to-apply Faston terminals. Can be used for as many as six individual circuits.

*Housing is fabricated of nylon for superior mechanical and electrical performance. UL approved.*

Write today for  
additional information.



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Oriental Terminal Products Co., Ltd., Tokyo, Japan.

# PIONEER ALUMINUM INC.

## announces new

# 921-T

# DC

## CAST ALUMINUM TOOLING PLATE

UNIVERSALLY ACCEPTED  
FOR PRECISION LOW COST  
TOOL ENGINEERING IN ALL  
METAL WORKING INDUSTRIES

*Direct Chilled* 921-T Cast Aluminum Tooling Plate is here, in sizes up to 60 inches wide, 192 inches long and 12 inches thick. Made exclusively by Pioneer Aluminum Inc., the new material is manufactured under processes which control solidification and provide greater density, less porosity and higher mechanical properties to augment the characteristics of standard 921-T.

Pioneer 921-T Cast Aluminum Tooling Plate meets every precision tooling requirement, and at lower cost. Its stability, versatility and workability save money and man-hours, being easily sawed, tapped, milled or welded. All Pioneer Cast Aluminum Tooling Plate\* is guaranteed within  $\pm .005$ " in thicknesses over  $\frac{3}{4}$ ". Write or call any Pioneer distributor for details, prices and engineering data.

\* Sizes up to 60" wide, 192" long, 12" thick, cast by the new Pioneer DIRECT CHILLED process.

AVAILABLE  
ALL OVER THE  
UNITED STATES

...through leading metal suppliers



**PIONEER ALUMINUM INC.**

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BIRMINGHAM, ALA.: Southern States Iron Roofing Co.  
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LOUISVILLE, KY.: Southern States Iron Roofing Co.  
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## NAUGATUCK Paracril

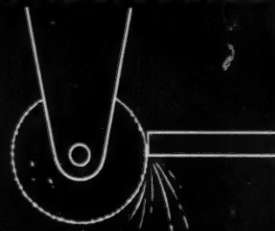
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*and now-*

**superior ozone resistance • greatly increased flex life  
• even higher abrasion resistance**

The secret of obtaining these valuable new properties in the vulcanizate lies in a method—recently developed by Naugatuck research—of compounding PARACRIL® with other inexpensive materials. The additives modify and fortify the PARACRIL, greatly expanding its range of application. For example, in the manufacture of hose intended to carry or be used around oil or petroleum

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The compounding secret that makes PARACRIL the ideal all-around oil-resistant rubber is available to PARACRIL users from Naugatuck's synthetic rubber and rubber chemicals technical representatives. Write or wire to have one of them call on you.



### Naugatuck Chemical

Division of United States Rubber Company, Naugatuck, Connecticut



CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario • Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latexes • CABLE: Ruboport, N.Y.

## Quenching and Tempering Alloy Steels

Of the various methods of heat-treating alloy steels, the most important is that involving quench and temper. This method, which enhances the mechanical properties of the end product, differs materially from normalizing and annealing (previously discussed in this series).

The purpose of quenching is to effect a cooling rate sufficient to develop the desired hardness and structure.

Before quenching takes place, steel is heated to a point above the transformation range. Quenching is the subsequent immersion of this heated steel in a circulated or agitated bath of oil, water, brine, or caustic; or, in the case of austempering or martempering, generally in agitated molten salt baths. Austempering and martempering are preferable where a minimum of distortion is desired.

Quenching *increases* the tensile strength, yield point, and hardness of alloy steels. It *decreases* ductility—that is, elongation and reduction of area. It also decreases resistance to impact. However, by means of tempering, it is possible to restore some of the ductility and impact-resistance—but only at a sacrifice of tensile strength, yield point, and hardness.

The results of mild oil- or water-quenching as related to mass effect can be found in the end-quench hardenability test. Voluminous data concerning this test are issued by AISI and SAE in the form of hardenability bands for the various grades of alloy steels.

If thermal cracking is to be avoided, cooling by liquid quenching should not be carried to a point below 150 deg F. When a temperature of 150 deg F is approached, im-

mediate tempering should follow. Because of residual stresses, no steel should be used in the as-quenched condition.

Tempering can be defined as reheating to a specified temperature below the lower critical range, followed by air cooling. It can be done in furnaces, oil, or salt baths, the temperatures varying from 300 to 1200 deg F. With most grades of alloy steel, it is best to avoid temperatures between 500 and 700 deg because of the "blue brittleness" that occurs in this range. Maximum hardness and wear-resistance result from tempering at low temperatures; maximum toughness is achieved by tempering at the higher levels. Of course, one of the essential reasons for tempering is to relieve the residual stresses set up in quenching.

Bethlehem metallurgists have devoted years of study to quenching, tempering, and other phases of heat-treating. By all means call them if they can be of service to you. And please remember, when you are next in the market for alloy steels, that Bethlehem makes all AISI standard grades, as well as special-analysis steels and the full range of carbon grades.

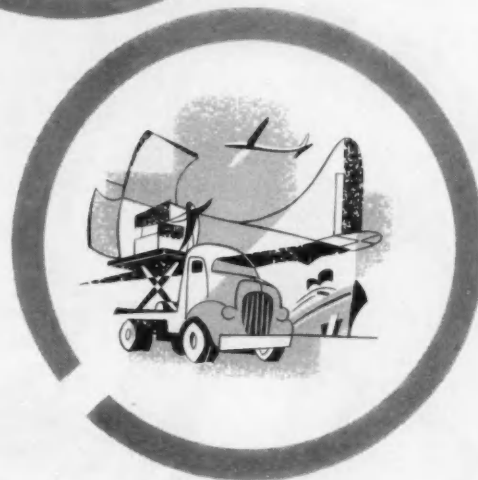
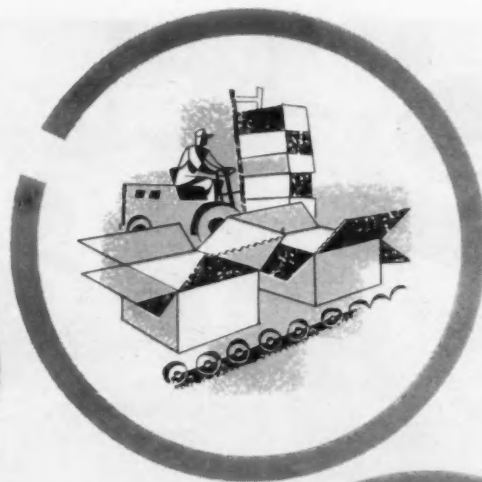
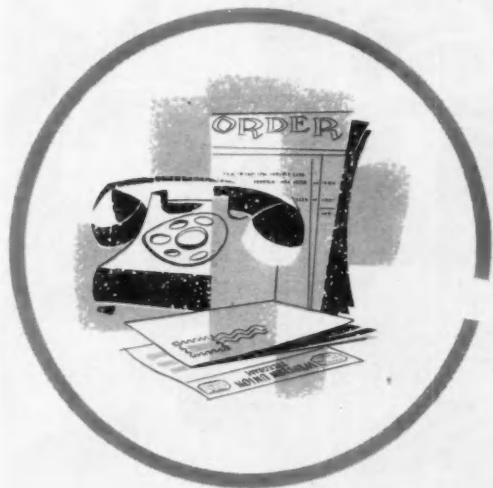
*If you would like reprints of this series of advertisements from No. 1 through No. XX, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 20 subjects in the series are now available in a handy 36-page booklet, and we shall be glad to send you a free copy.*

BETHLEHEM STEEL COMPANY  
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation



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*that stays ahead of your production deadlines*

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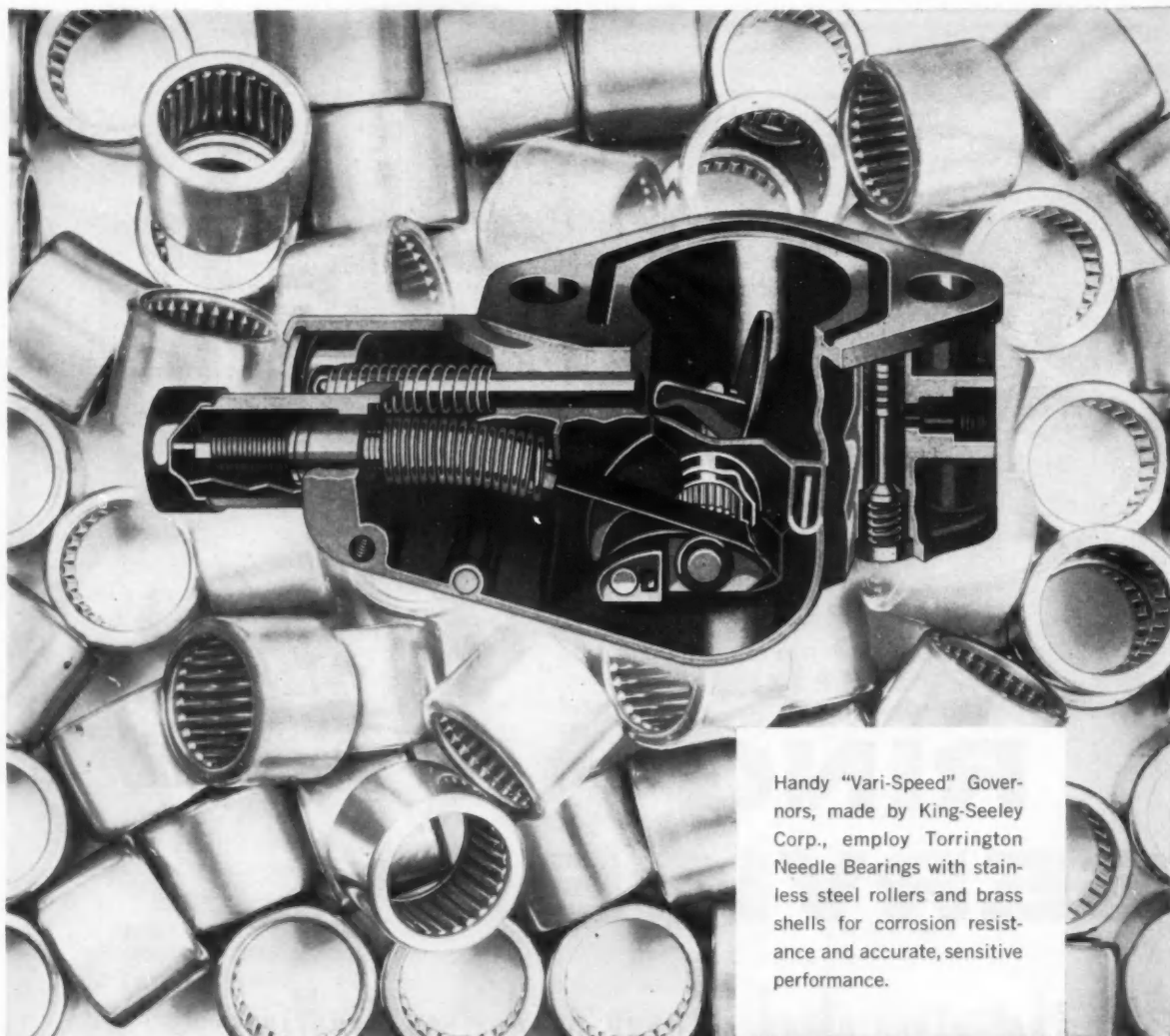


**McQUAY-NORRIS**

MANUFACTURING COMPANY

St. Louis • Toronto

*Largest Producer of Small Rings in the Automotive Industry*



Handy "Vari-Speed" Governors, made by King-Seeley Corp., employ Torrington Needle Bearings with stainless steel rollers and brass shells for corrosion resistance and accurate, sensitive performance.

## Twenty years later— still preferred!

Since the first installation before World War II, Torrington Needle Bearings have been used in Handy "Vari-Speed" Governors. These units govern engine speed for automobiles, trucks and buses by balancing air-flow pressure on the throttle plate against a calibrated cam-spring mechanism.

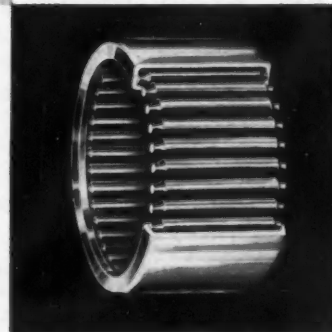
Torrington Needle Bearings were first used to insure sensitive response and regulation at low velocity and tension values—and are still preferred. They provide efficient anti-friction operation in the simplest and most compact design possible.

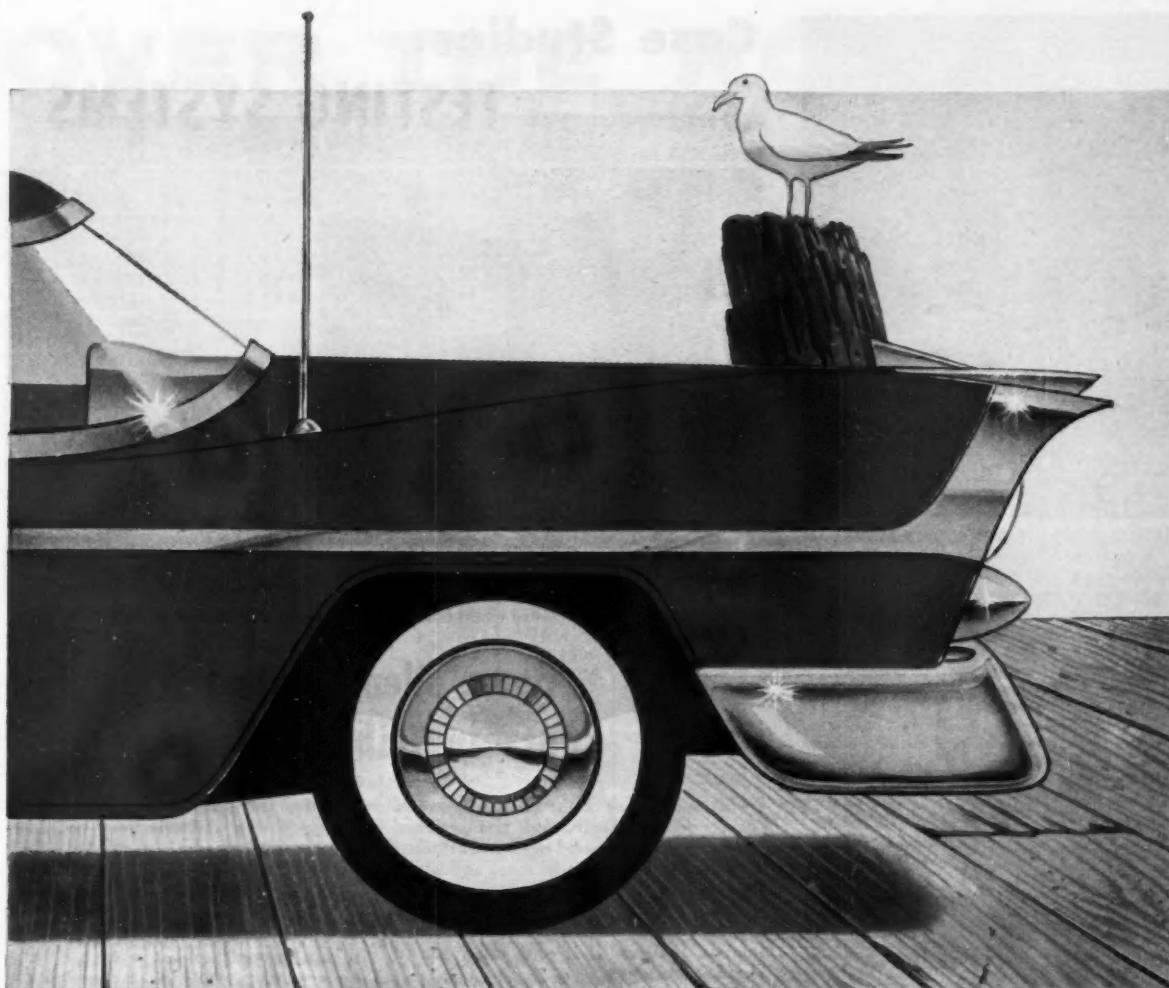
In every type of service, Torrington Needle Bearings have provided long, trouble-free and dependable service—as in so many other automotive applications. For engineering assistance on your requirements, see your Torrington representative. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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How do you get unlimited flexibility in designing tomorrow's body and parts? You need a metal with beauty, strength, rigidity, lightness and superior resistance to corrosion. You need stainless steel.

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Free *Stainless Steel Selector* contains complete data: nominal composition of all grades • physical properties • resistance to corrosion, scaling • data on machining, welding, hardening. Write: *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*



# CRUCIBLE

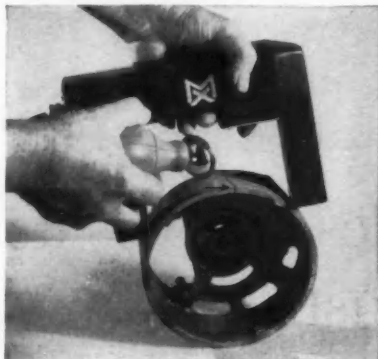
first name in special purpose steels

## Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.



**ZYGLO INSPECTS MISSILE RADOMES IN 2 MINUTES**—Costly ceramoplastic parts for guided missiles are checked out for perfection in a minimum of time for one electronics manufacturer. When the telltale fluorescent indication shows up under "black light", inspectors know Zyglo has uncovered another defective component. In the case of the radomes, hundreds of dollars are saved by rejecting in the rough molded stage—before costly finishing operations are expended on parts destined for the scrap heap. Early detection also enables this manufacturer to correct processing errors before additional faulty parts are produced. Zyglo serves not only as an inspection tool, but as an "in-process" control check-point as well.



**Y-5 PROVIDES "SECOND SIGHT" FOR INDUSTRY**—For on-the-spot detection of crack-type defects in rough castings, we know of one company which puts low cost Magnaflux Y-5 Yoke Kits in the hands of their lathe operators. If a part is suspect, it can be quickly checked during "in-process" turning operations. This industrial "fore-sight" eliminates wasted time and effort on defective parts. Results: greater production economy and real product confidence.

**HALLMARK  
OF QUALITY IN  
NONDESTRUCTIVE  
TEST SYSTEMS**



Write for complete details concerning any of the above case studies, (excerpts from MAGNAFACTS), or ask for our new booklet on Lower Manufacturing Costs.

## Case Studies: NONDESTRUCTIVE TESTING SYSTEMS



Checking a printed circuit base with a Magnaflux SO-100 Sonizon Unit

### How "silent" sound spots invisible defects

Sonizon, another of the many Magnaflux developed nondestructive test systems, is currently being used to detect hitherto unmeasurable defects in many industrial products. This ultrasonic test instrument employs high frequency impulses to detect sub-surface discontinuities in metals, plastics, glass and other sound conductive materials.

Sonizon is lightweight, portable, easy to use. This remarkable ultrasonic instrument measures thicknesses from one side only and shows readings as a "pip" on the face of a TV-type tube as rapidly as a crystal probe is touched to the test materials. It is as easy to read as a ruler, and besides being far faster than a micrometer, Sonizon

provides the additional advantage of giving you a reliable way to make otherwise impossible readings on complex shapes.

Sonizon reduces inspection and production costs by instantly detecting such bothersome defects as: "thin walls" in cast, formed, welded or spun objects; laminar discontinuities; eccentricity in cored castings and cast iron pipe; and, lack of bond between materials used in "sandwich" construction.

If your production efforts are hampered by similar critical defects, it will pay you to investigate Sonizon today. Write for complete information, or request an interview with one of our experienced Magnaflux field engineers.



Sonizon is used in the automotive industry to detect lack of bond between valve lifter bodies and carbide wear plates.

Sonizon quickly and reliably detects any variance of taper dimensions in a machined cast magnesium cone.

Sonizon is used in aircraft maintenance to determine possible corrosion on the wing skin of planes, during regular major overhauls.

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MODEL	Cyl.	*Features	Bore and Stroke	Displ. Cu. In.	Max. Torque @ RPM	Max. HP	RPM
197-DLCS	6	ATV	4 x4	302	275-1800	131	2800
135-DKBS	6	ACTV	4 1/4 x5	426	400-1800	185	2800
148-DKBS	6	ACTV	5 1/4 x6	779	706-1800	280	2100
WAKDBS	6	ACTV	6 1/4 x6 1/2	1197	1062-1600	352	1800

NORMAL DIESELS							
180-DLC	4	AC	3 1/2 x3 3/4	144	102-1800	45	2400
185-DLC	6	A	3 1/2 x3 3/4	216	152-1000	60	2400
190-DLCA	6	AC	3 3/4 x4	265	191-1400	84	2800
195-DLCA	6	AC	4 x4	302	221-1800	98	2800
197-DLC	6	AV	4 x4	302	216-1600	91	2800
135-DKB	6	ACV	4 1/4 x5	426	328-1600	147	2800
148-DKB	6	ACV	5 1/4 x6	779	584-1000	200	2100
WAKDB	6	ACV	6 1/4 x6 1/2	1197	845-1000	258	1800

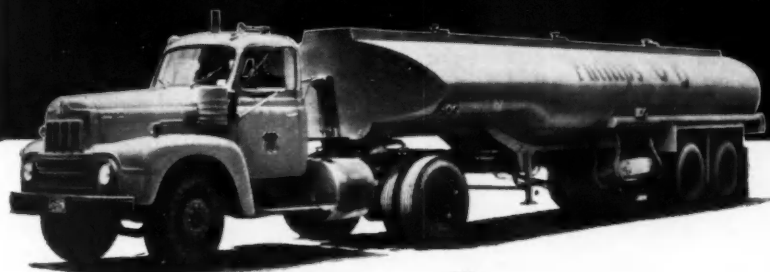
GASOLINE							
180-GLB	4	AC	3 1/2 x3 3/4	144	118-1600	45	2400
185-GLB	6	A	3 1/2 x3 3/4	216	176-1400	67	2400
190-GLB	6	A	3 3/4 x4	265	223-1200	77	2400
195-GKA	6	ACV	4 1/8 x4	320	244-1400	122	3000†
MZA	6	A	4 1/4 x4 3/4	404	289-1000	128	2800†
135-GKB	6	ACV	4 1/4 x5	426	337-1200	147	2800†
135-GZB	6	ACV	4 3/8 x5	451	354-1200	153	2800†
140-GKB	6	ACV	4 1/2 x5 1/2	525	426-800	177	2600†
140-GZB	6	ACV	4 3/4 x5 1/2	554	453-800	188	2600†
145-GKB	6	ACV	5 1/4 x6	779	594-1000	240	2400†
145-GZB	6	ACV	5 3/8 x6	817	652-1200	260	2400†
WAKB	6	ACV	6 1/4 x6 1/2	1197	997-1000	280	1800

\*FEATURES: A—Aluminum Alloy Pistons; C—Counterbalanced Crankshaft;  
T—Turbo-Supercharged; V—Vibration Dampener.

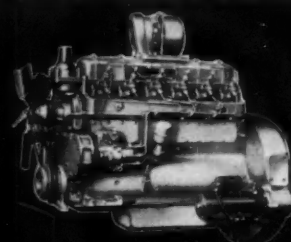
†These engines rated at higher hp and rpm for fire engine service. Send for Bulletin 1079 for LPG ratings and complete listing of engine hp and speed ratings.

# WAUKESHA ENGINES

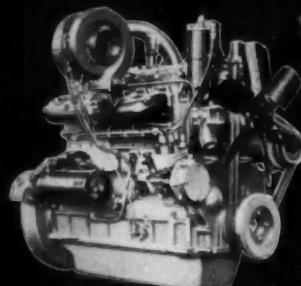
**NORMAL and TURBOCHARGED DIESELS  
... GASOLINE ... LP GAS  
Standard or Counterbalanced Crankshafts**



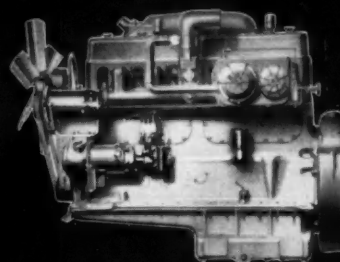
361



197-DLCS—Turbocharged Diesel  
(Also normally aspirated)



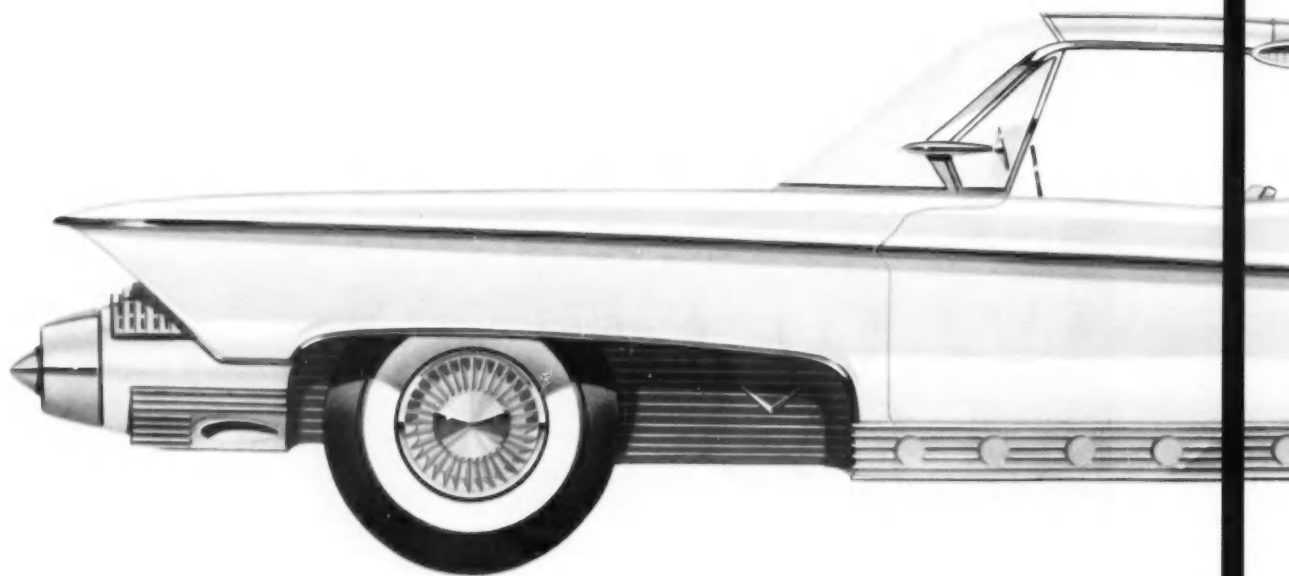
135-DKBS—Turbocharged Diesel  
(Also normally aspirated)



WAKB—Equipped for butane

*Write* for descriptive bulletins  
**WAUKESHA MOTOR COMPANY**  
Waukesha, Wisconsin  
New York • Tulsa • Los Angeles

***Exterior:** The Piedmont side view presents bold, straight-through styling in aluminum! Bright, full-length rub strip is integral with the stamped aluminum body panels and one-piece cast aluminum door. Anodized finish assures permanent beauty without painting. Ribbed lower side trim is exposed portion of cast aluminum frame. Wheel wells are ridged aluminum stampings; colored vinyl fills hollows between ridges. Decorative finned casting behind front bumper is aluminum exhaust muffler. Bumpers are cast and extruded aluminum. Retractable hardtop of aluminum sheet, forgings and castings folds to half its length, disappears into rear deck. Roll-away deck cover of aluminum extrusions and neoprene joining strips leaves opening unobstructed.*

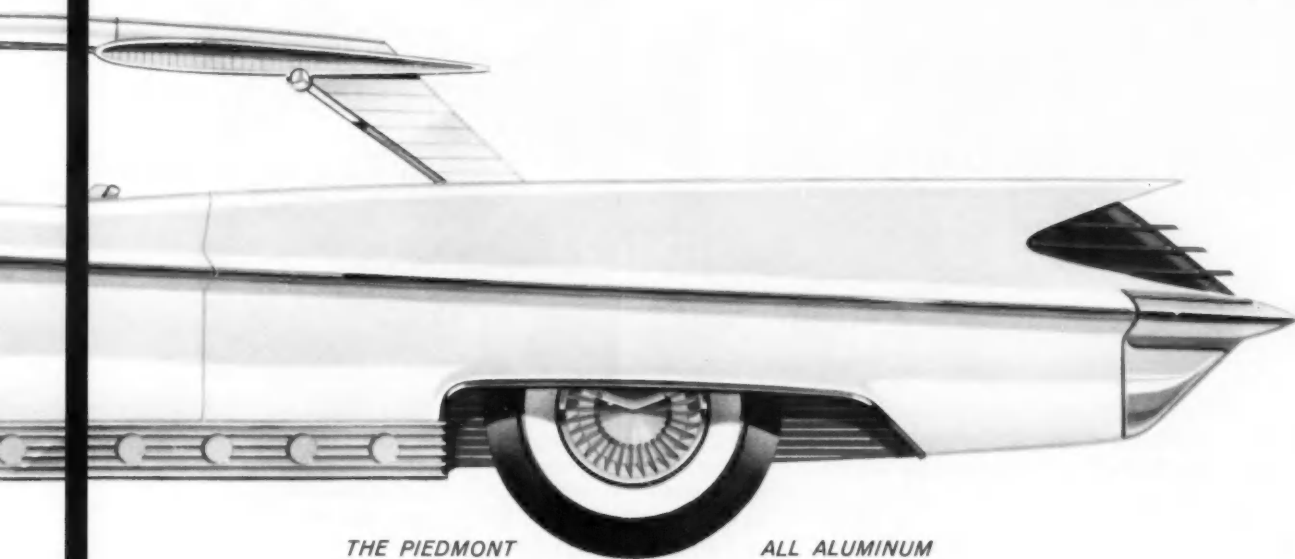
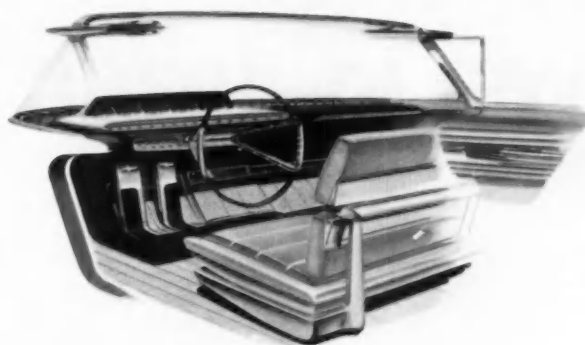


## A KAISER ALUMINUM DESIGN

This Kaiser Aluminum design represents a concept of a car for the immediate future. Its purpose is to suggest aluminum's versatility . . . aluminum's infinite range of automotive design possibilities. The applications shown are logical, within the realm of present possibility.

Kaiser Aluminum will be pleased to work with you as your "idea partner" for further development of ideas suggested by this design.

*Interior:* The Piedmont's interior presents an inspiration for experiment from firewall to seat back! Firewall, toe-board and panel parts are integrated into a single aluminum casting. This casting also includes heater-ventilator grilles and all necessary bosses and studs (for easy assembly). Speedometer numerals are cast into instrument cluster housing. Floorboards feature cast-in texture and pattern to eliminate need for carpeting, and all corners can be full-rounded to simplify sweeping and cleaning. Inner door panel shows another example of cast-in texture and trim with permanent anodized color. Seat frame of forged aluminum permits very light construction with sculptured styling. For the pivoted backrest, the seat back may be stamped, cast or extruded of aluminum, with unlimited variations of formed-in texture available for decorative trim.

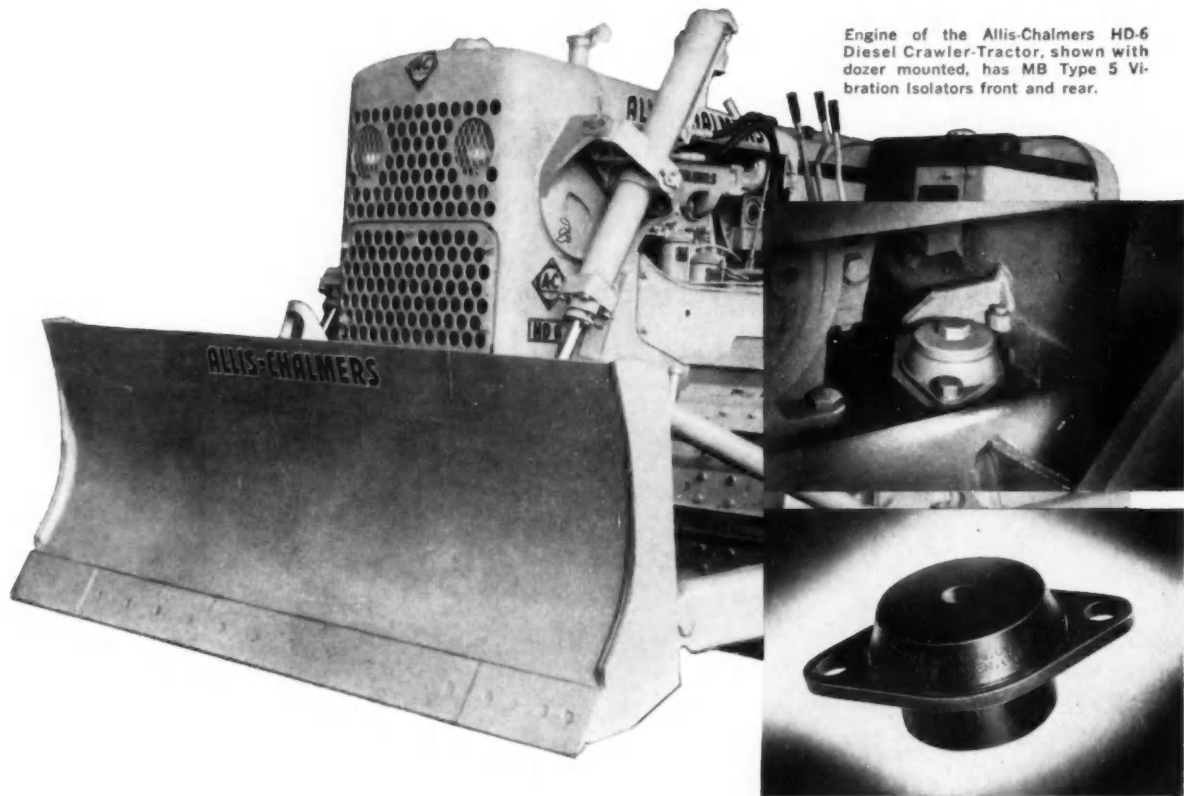


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# MB engine mounts work even in dozer service



Engine of the Allis-Chalmers HD-6 Diesel Crawler-Tractor, shown with dozer mounted, has MB Type 5 Vibration Isolators front and rear.

**T**HE Allis-Chalmers Model HD-6 crawler tractor has the distinction of being one of the first tractor dozers having successful isolation of engine. Many an operator of the dozer can thank use of a main frame and Isomode® Type 5 Mounts for the improvement.

Why is this application so hard on a mount? Obviously, the mount must be capable of surviving severe shock. It has pitching tortuous motions to endure. It is subjected to distortion, to bursts of power and high engine torque.

The MB Type 5 Mount performs to a principle developed by MB specialists over 10 years ago.

It has an equal spring rate in all directions, thus equally isolating the six possible modes of vibratory motion. With its core in balanced compression and shear, it offers high load capacity and endurance in compact size; and is safely self-snubbing to control damaging overloads.

MB concentrates on mounts which start where ordinary units have to give up. While *standard* units are available, MB mounts are actually in the *special performance* class. Perhaps we can work out a modification of one to solve *your* troublesome vibration problem. Send for Bulletin 616A. ® registered trademark.

***MB manufacturing company***

*A Division of Textron Inc.*

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North American's F-100 Super Sabre is designed to operate in extremes of cold, heat, and altitude. And that makes Auto-Lite 350 silicone-rubber-insulated wire about perfect for the job.

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Many airframe manufacturers are finding that Auto-Lite 350 Wire reduces over-all production costs, too, compared with other types of high temperature wire.

- Flexible at temperatures below -80°F.
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- No discoloration at maximum operating cable temperatures
- Flame-resistant
- Easy printing of circuits with conventional marking machines
- Meets Spec. MIL-W-8777, U.S.A.F.
- Free stripping
- Manufactured in sizes 22 thru 2/0

For complete information on Auto-Lite Aircraft Wire, including specifications and samples, write to . . .  
The Electric Auto-Lite Company, Wire and Cable Division, Port Huron, Michigan or Hazleton, Pennsylvania

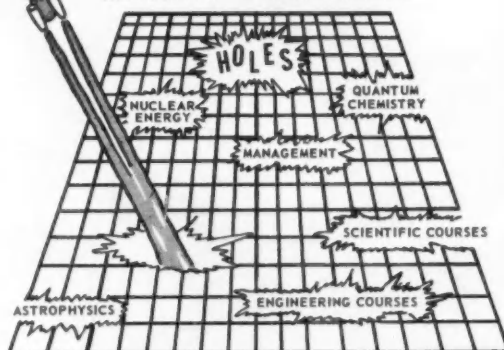


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## LOW TEMPERATURE TESTING OF ELASTOMERS

Compiled By

Charles M. Miller, Chairman  
AMS Non-Metallic Material Committee  
and

Dr. Willis O. Gordon, Northrop Aircraft

August 15, 1956

\$1.50

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ACTUAL SIZE

GOLD on BLUE ..... Member Grade  
GOLD on RED ..... Associate Grade  
GOLD on WHITE ..... Junior Grade

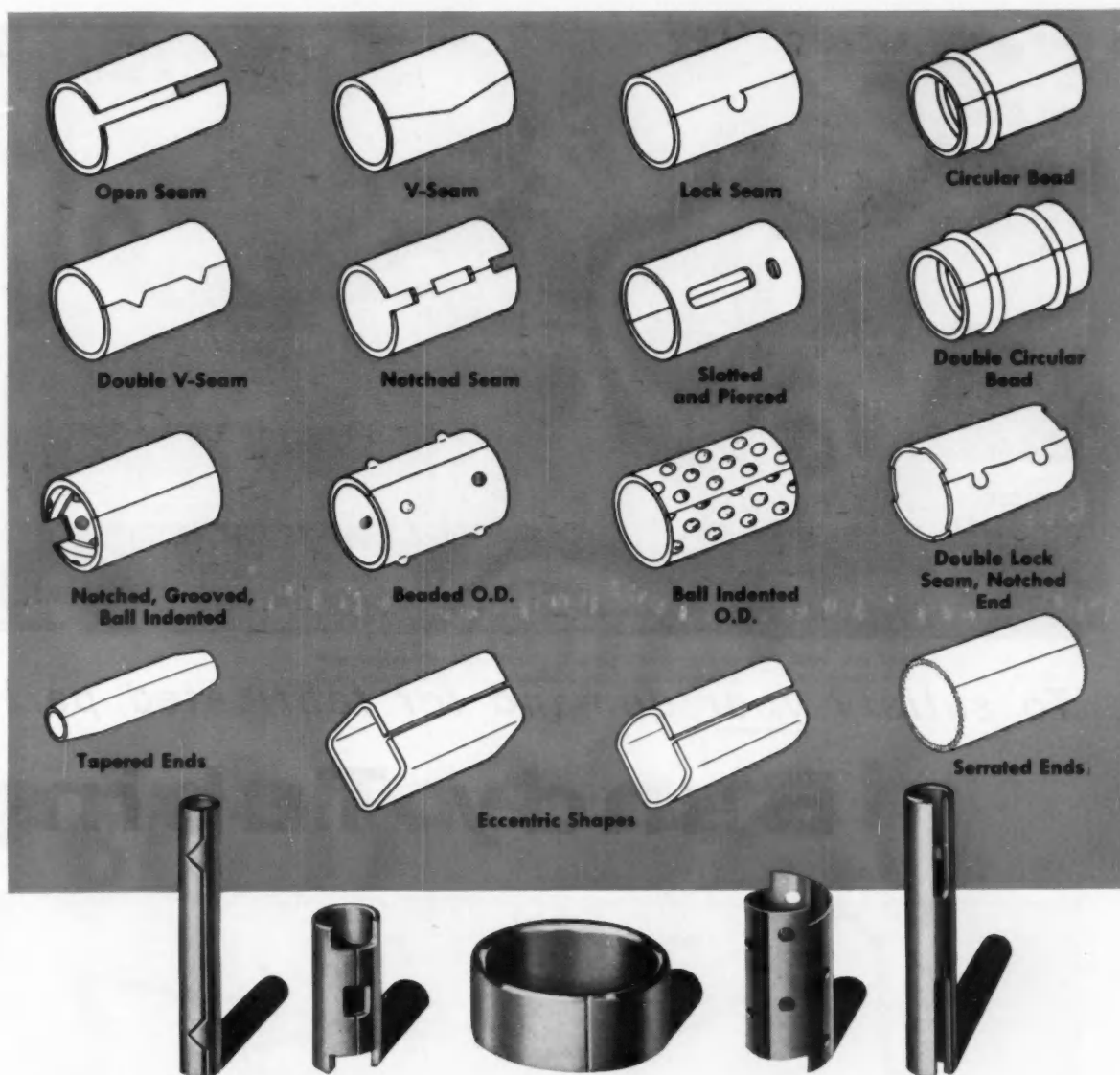
Society of Automotive Engineers  
485 Lexington Ave., New York 17, N. Y.

Please send me an SAE emblem. Enclosed is my check for \$ ..... (\$1.50 plus applicable taxes).  
Grade of membership (please check)

☐ Member ☐ Associate ☐ Junior

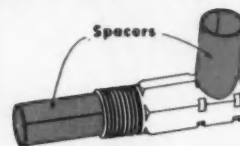
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Used in hundreds of automotive, appliance, farm implement and wheeled goods assemblies, they save time, labor and costly materials. An economical substitute for iron pipe, tubing or machined parts, they are delivered ready for assembly, to exact dimensions. A special catalog with design data is available, without obligation. Address:

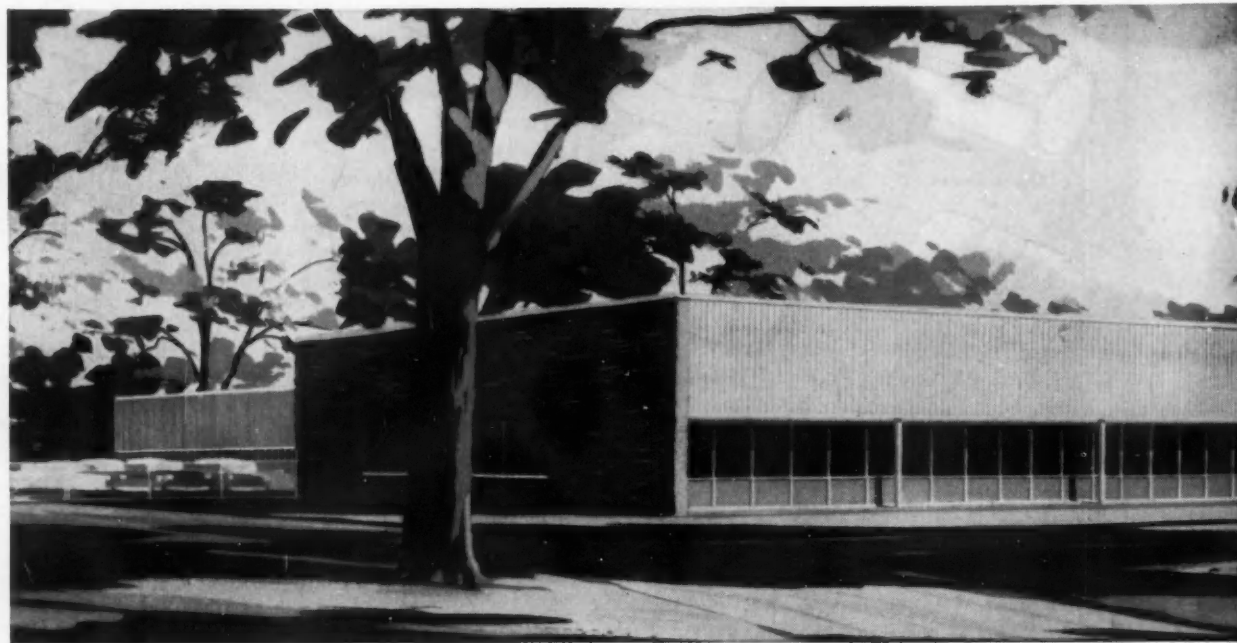


Spacers can be furnished with brazed seams and we can braze spacers to other components, as shown here.

# FEDERAL-MOGUL DIVISION

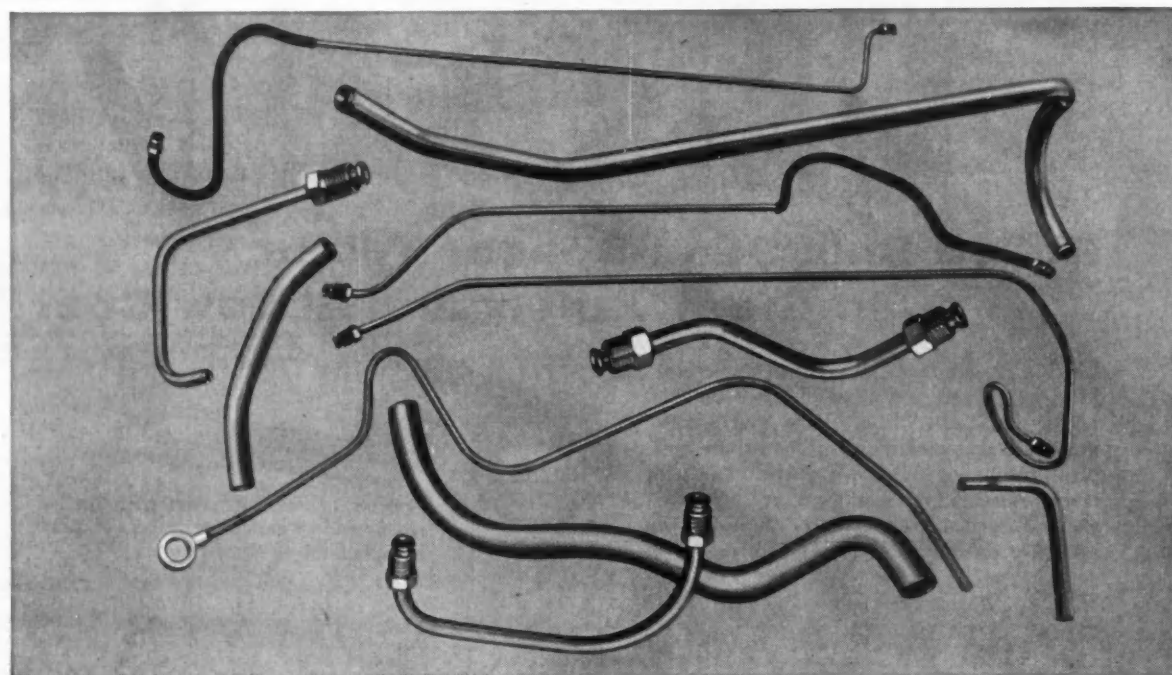
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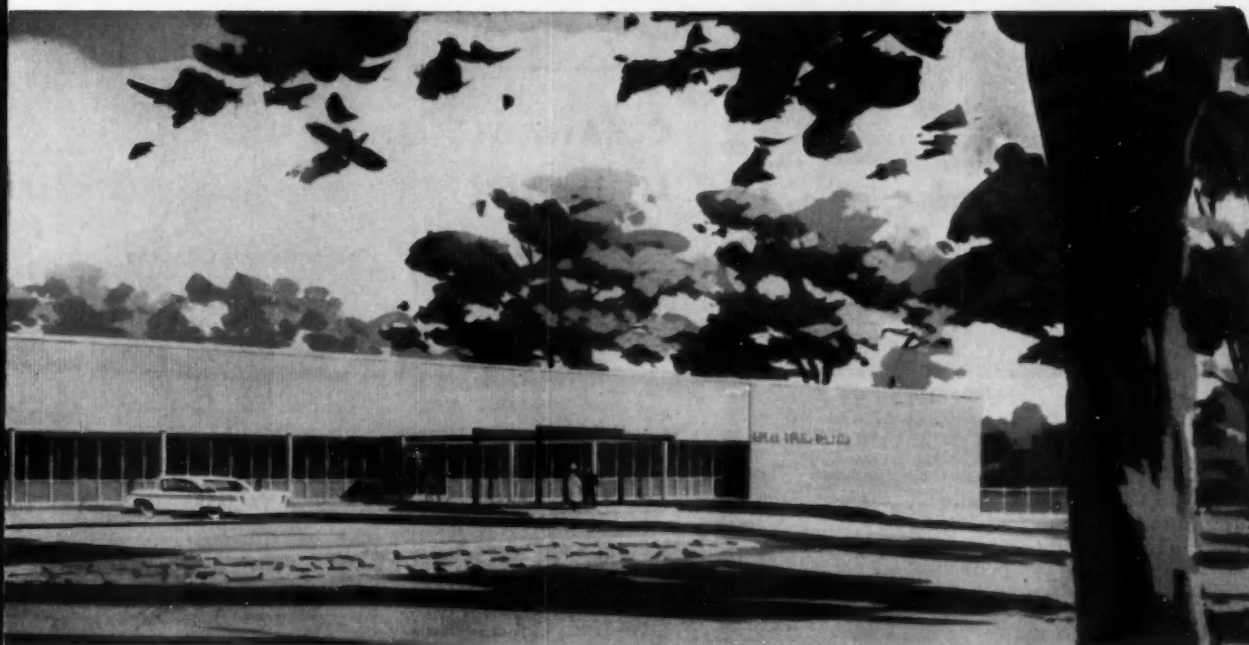
*To satisfy your demand for fabricated parts:*

# Bundy Tubing



These typical automotive tubing parts now are in mass production at Bundy's new Winchester Division. Strong, leakproof Bundyweld Tubing,

fabricated into a variety of complex shapes, is used on 95% of today's cars, in an average of 20 applications each.



Winchester Division, Bundy Tubing Company's newest plant, has 103,500 square feet of floor space devoted exclusively to fabricating parts from famous Bundyweld® Tubing.

# expands again

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**Experienced personnel**—Highly trained production operators . . . long-time Bundy men in key supervisory slots.

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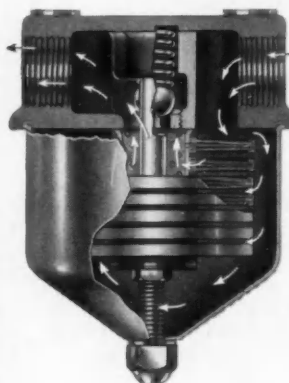
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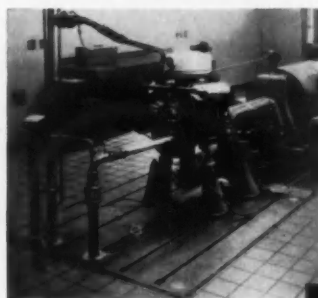
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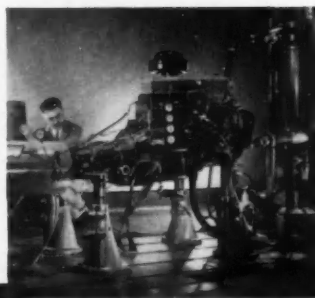


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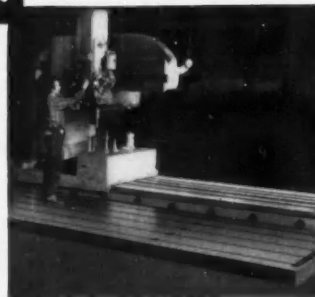
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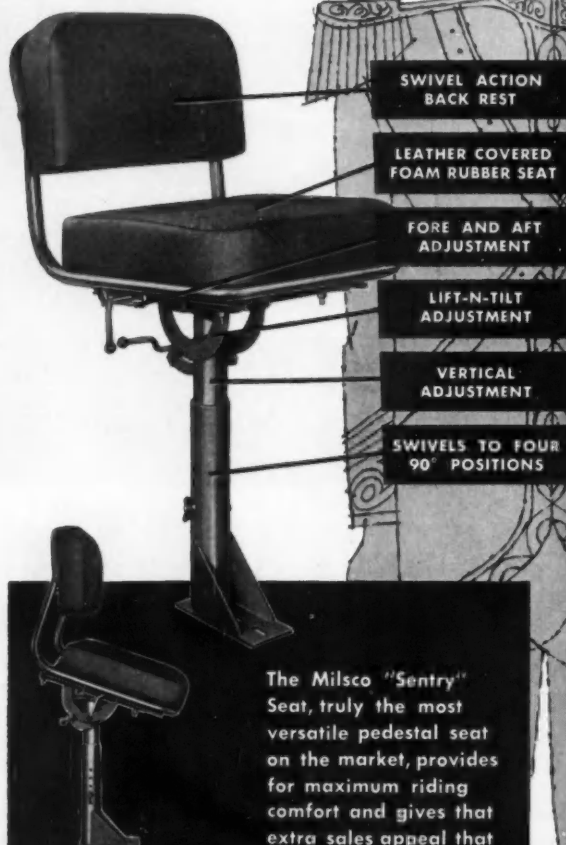
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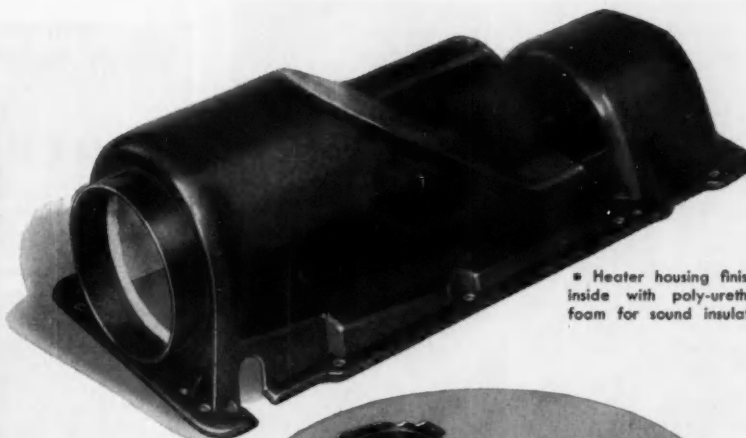
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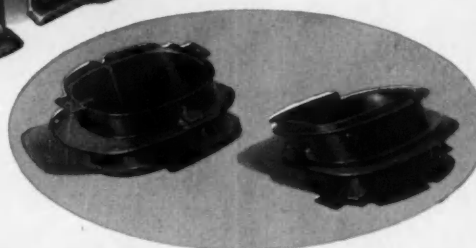
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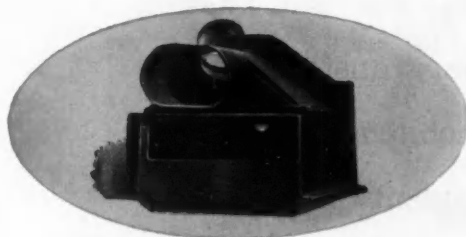
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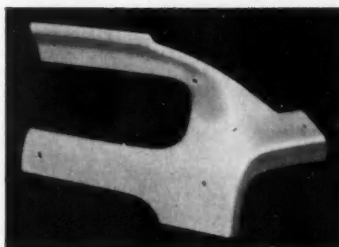
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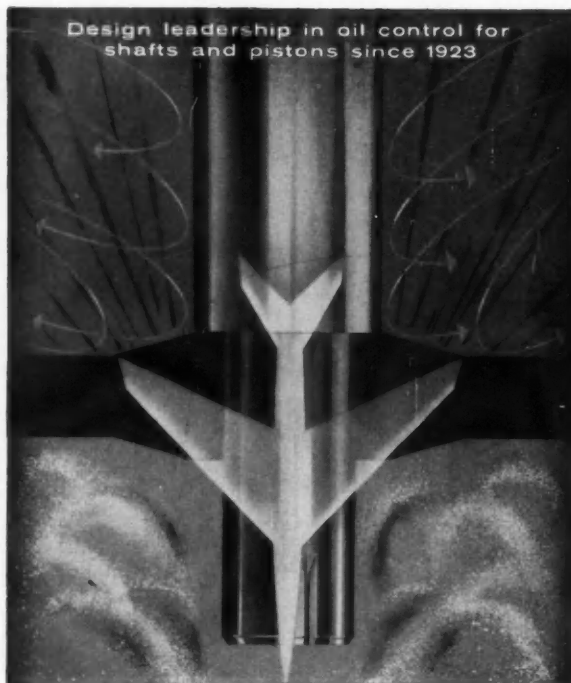


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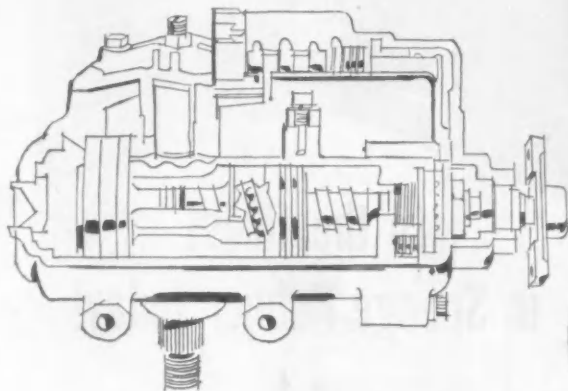
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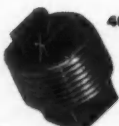
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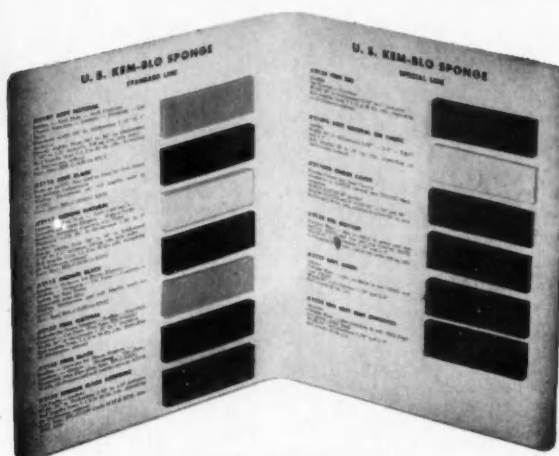


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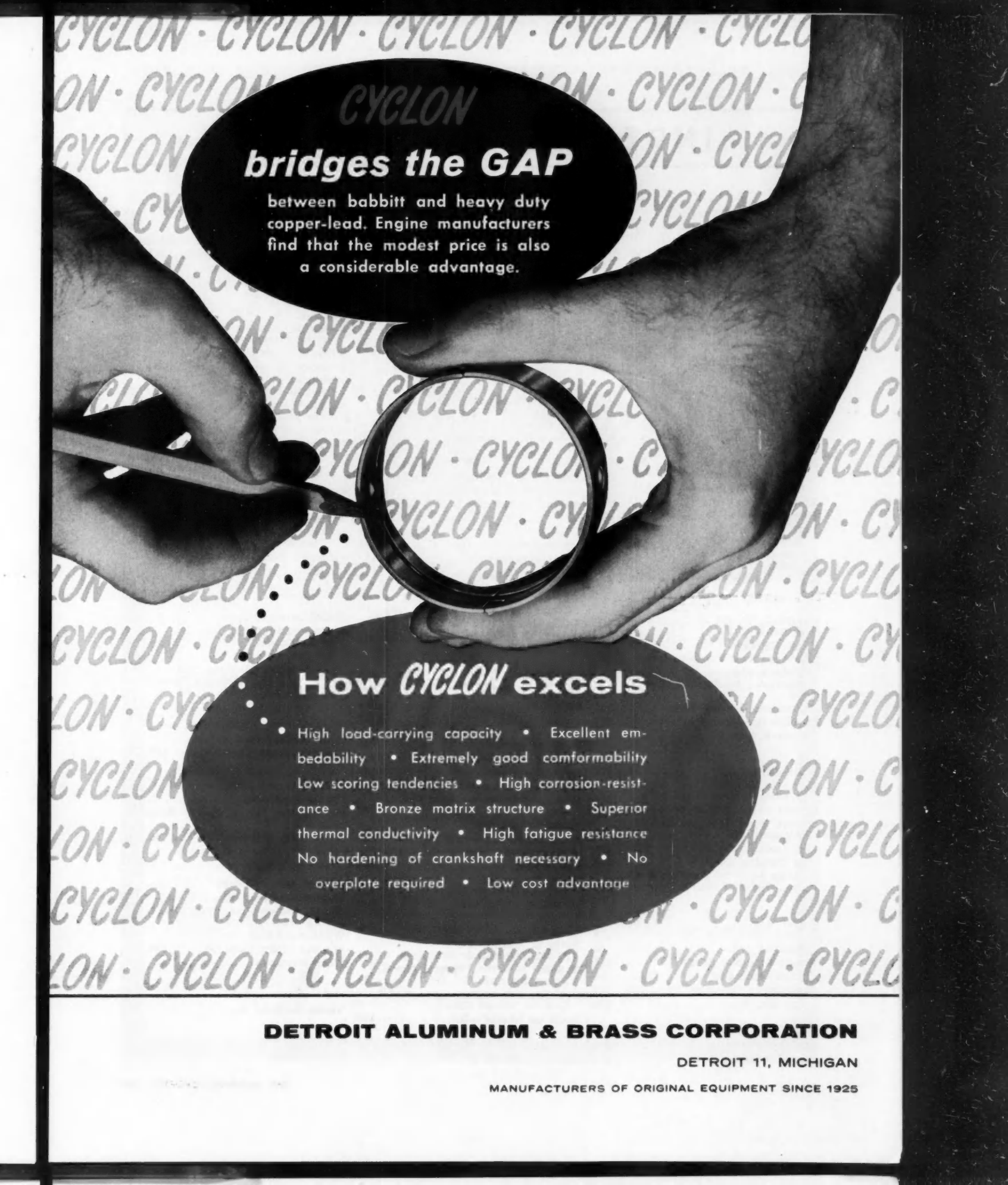
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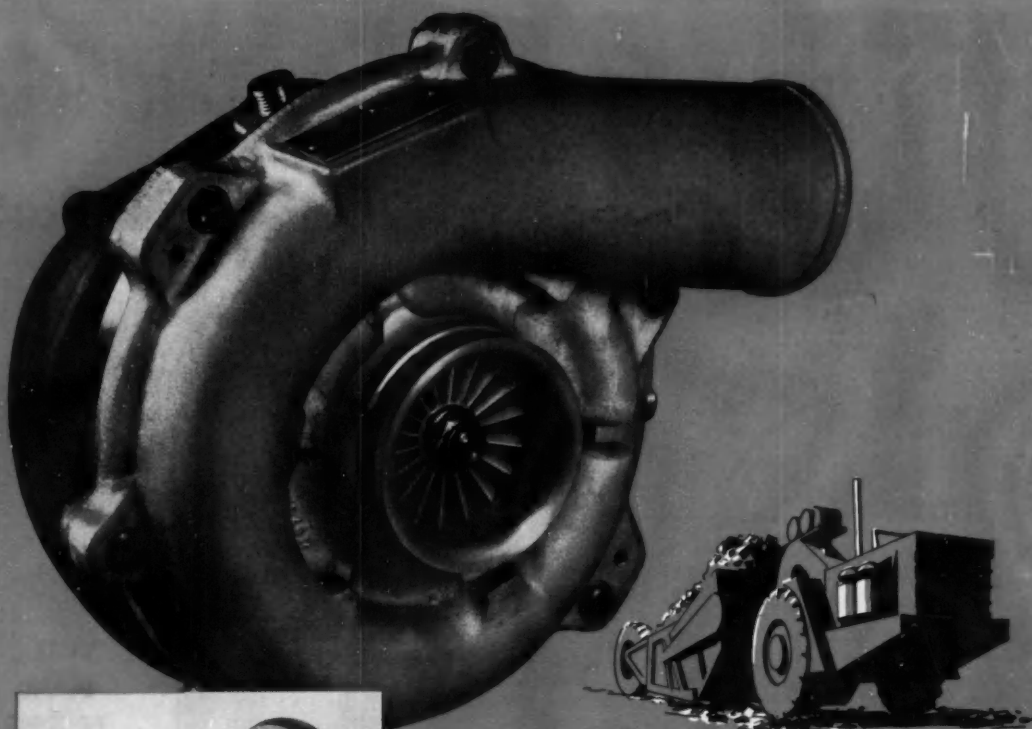
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MANUFACTURERS OF ORIGINAL EQUIPMENT SINCE 1925

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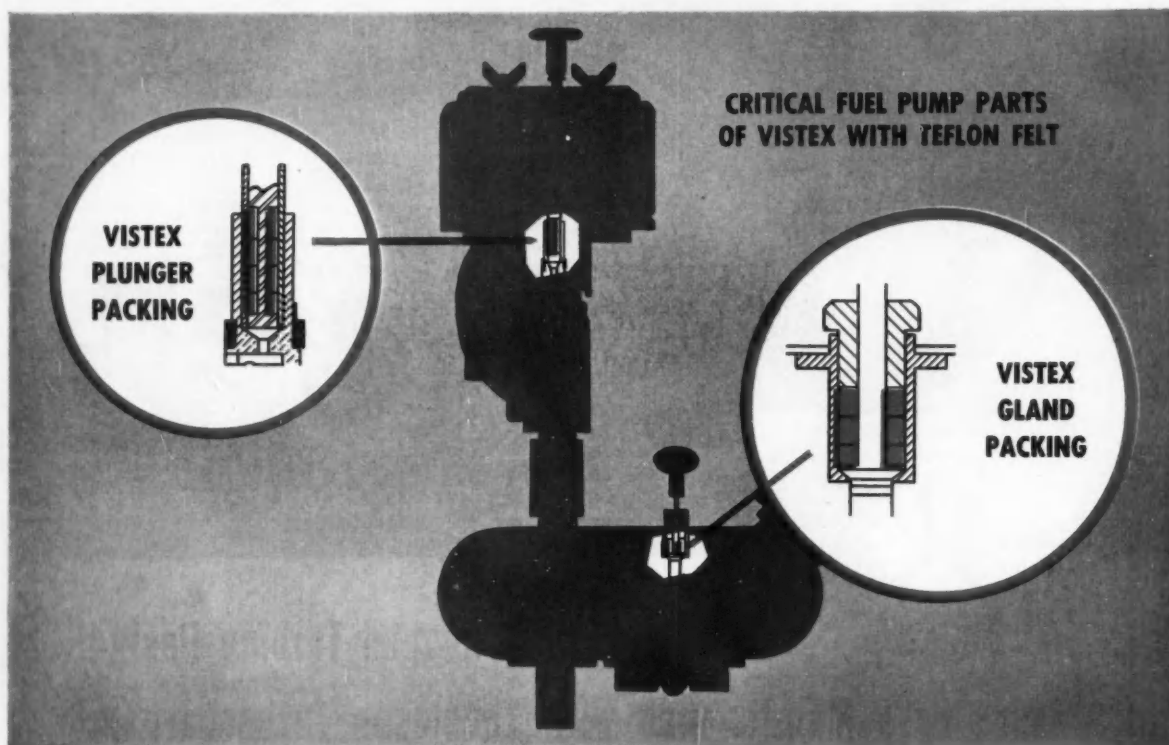


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for positive . . . self-lubricating seals



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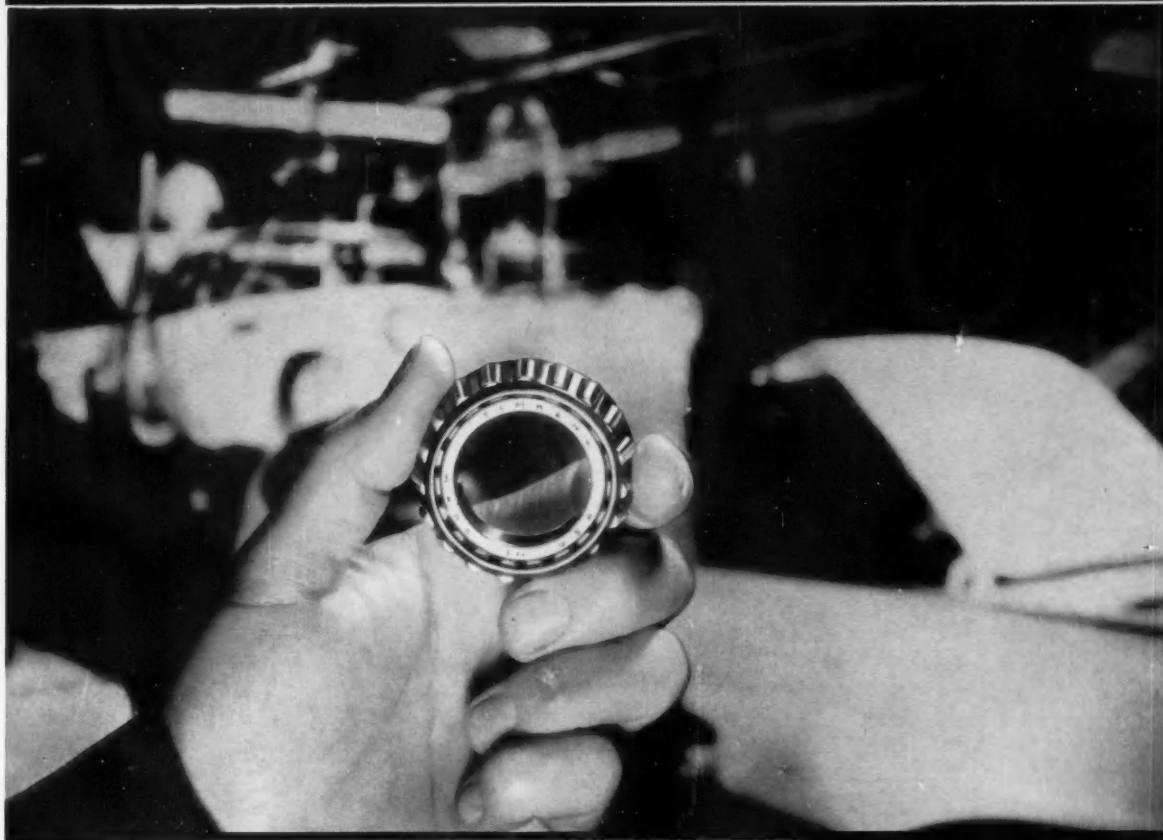
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### Get a better bearing and save up to 15%

**L**ONGER, lower, sleeker, faster, more powerful cars are revolutionizing the automobile industry. And the new cars coming off the production line (above), place new and greater demands on component parts. Meeting the big change in cars is the big change in bearings—Timken and the Moto-Mated Way. It's a whole new concept in bearing design, manufacture and supply—*mated* to the needs of the dynamic automotive industry.

From the Moto-Mated Way comes a new breed of Timken® tapered roller bearings in 13 standardized sizes. New, lighter bearings to reduce unsprung weight. Smaller bearings that save space—permit more compact design. Bearings that are capacity packed to take the increasing loads of driving today's powerful cars.

And because they are produced by

machinery and methods revolutionary in the bearing industry, the new bearings cost less. They give automakers an area of economy in their otherwise spiraling manufacturing cost.

Carmakers have already saved 14.6% in bearing costs for millions of front wheels on 1957 cars. And savings up to 15% are possible as designs are adapted to make use of Timken Moto-Mated bearings in rear wheels, pinions and differentials. As your use of the new bearings grows, we can pass still further manufacturing savings along to you.

Whether you're designers, production engineers or purchasing men, now, more than ever, Timken bearings are your No. 1 value. The Timken Roller Bearing Company, Canton 6, O. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO".



QUALITY, SERVICE, PUBLIC ACCEPTANCE MAKE

# TIMKEN

TAPERED ROLLER BEARINGS

YOUR NO. 1 BEARING VALUE